LECTURES ON SCIENTIFIC METHOD

B.N. Ghosh

The book is an outgrowth of classroom lectures on the scientific method delivered to undergraduate and post-graduate students over a number of years. It contains the basic principles and practices of the scientific method and aims at acquainting the students with the fundamental concepts and precepts of the subject. It is an analytical study of different facets of the scientific method.

In both depth and range, the book covers a very wide area. The treatment of the subject matter is exceptionally lucid and incisive, simple and thorough. The book can serve both as an introductory text and as a reference book for undergraduate and postgraduate students studying in universities in India and abroad.

Rs 75

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STERLING PUBLISHERS PRIVATE LIMITED
NEW DELHI-110016
BANGALORE-560001

STERLING PUBLISHERS PVT. LTD.
L-10, Green Park Extension, New Delhi-110016
24 Race Course Road, Bangalore-560001

Lectures on Scientific Method

Published by S.K. Ghai, Managing Director, Sterling Publishers Pvt Ltd., L-10 Green Park Extension, New Delhi-110016. Printed at Print India, A-38/2, Mayapuri, Phase-I, New Delhi-110064

PREFACE

Scientific Method has become an independent course of study in many Indian Universities at the Undergraduate level for both Arts and Commerce students. Books on Scientific method are by no means scarce in supply but it is really difficult to come across any book which can meet the requirements of our budding, tender and somewhat immature but teeming millions of growing students of our population. The present book seeks to serve the purpose of undergraduate level students for their course on Scientific Method.

The book is a collection of my lectures delivered to my students of the subject over a period of twenty long years in various educational institutions in India. It contains all the relevant topics and materials, and written according to syllabi of Indian Universities. It is primarily meant for the B.A. students of philosophy and B.Com students of Delhi University. Needless to say, it can be effectively used by the undergraduate students of philosophy of all Indian Universities. It is primarily designed as a text book; but it can also be used as a reference book for the students of subject of scientific method which is taught in some specialised courses nowadays in many of our universities. For instance, the subject is taught in M.A. (Eco.) as a compulsory paper in Kurukshetra University (Kurukshetra), M.D. University (Rohtak), Madras University (Madras) and in a few more universities of India. The Content of the book is designed in such a way that the students of these universities can successfully utilise this. Scientific Method is the basis of a scientific mind. Hence, it deserves to be read *ab ovo* by the serious students and researchers of all categories.

The book is written in a very lucid and simple style so that no external help is required to understand the subject. It covers a very broad area of the subject in both depth and range. The book incorporates the traditional as well as modern ideas and theories on the subject. This particular feature of the book alone can give it a superiority over the available books on the subject.

The book owes its origin to my students whose request it has been to give it shape. Its publication has been possible within so short a period because of the untiring efforts of Shri S.K. Ghai of Sterling Publishers, Delhi. I express my sincere gratitude to him. I will consider my efforts amply rewarded if it comes to the help of our students. Any suggestion for the improvement of the book will be highly appreciated.

1985

B.N. GHOSH

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SCIENCE AND KNOWLEDGE

THE MEANING AND NATURE OF SCIENCE

Meaning

A science is a body of systematic knowledge. A science is a system of knowledge. A system consists of a number of things which are related together in a particular way so as to serve a particular purpose. The proper understanding and explanation of facts lead to the development of science. There is an inherent urge to know and understand facts, and this is done by relating the facts together. A meaningful relationship between facts is established through rational explanation. Explanation becomes the basic feature of sciences. The ideal of science is to achieve systematic inter-connection of facts.

The finding out of inter-connection of facts is the first significant step towards the development of systematic knowledge which a science represents. The relating of facts is done in science by connecting them to laws. The search for laws is one of the important distinguishing features of every science. In fact, this aspect differentiates science from the ordinary knowledge. In science, laws are explained by constructing theories which relate the laws into a system.

But the formulation of laws or the construction of theories is not simply a matter of observation. It involves reflection, and reasoning. A science is also self-corrective in nature. If new facts are discovered and new reasoning is developed, the old conclusions are revised and reformulated. With the help of developed laws, a science undertakes predictions as to the future course of certain events. The power of prediction constitutes one of the important functions of a science.

Broadly, there are two types of sciences : (i) formal or deductive (ii) empirical or inductive. In the first type, the system

is developed through definitions, axioms and inference from which conclusions are developed from the deductive method of reasoning. Pure Mathematics is an example of formal science. But Physics is an example of an inductive science, because it is based on facts which are given by experience. There is no choice of facts, and facts are developed primarily by the inductive process of reasoning. Empirical sciences are based on experience which means knowledge obtained by observation. The facts of material world studied by Physics, and the facts about human life that social sciences, like Economics, study are based on observation. In all empirical sciences, verification plays an important role in the search for the attainment of truth, which is the ultimate aim of all sciences.

Presuppositions of Science

Presuppositions are assumptions for the establishment of truth. Presuppositions are essentials before conducting an investigation. There are the following presuppositions of a science : (1) Nature is real, (2) Nature is orderly, (3) Principle of Simplicity or parsimony, (4) Principle of causality and (5) Principle of Uniformity of nature.

There is the existence of the physical realm. A scientist must believe in the reality of nature or world. Without such a belief, he cannot conduct observation and experiment. This faith is the basis of all natural sciences.

A science always believes the fact that nature is orderly, i.e. there is always order in nature. Such a belief helps the scientist to find out a causal link between the different facts. Thus, the belief becomes the basis of hypothesis and verification. The particular order involved, however, has to be found out by the scientist.

The principle of simplicity suggests that entities should not be unnecessarily multiplied. They should be as simple as possible. This is called *Occam's Razor*. It means that no causes are to be assumed than what are necessary to explain the phenomena. This principle involves the economy of thoughts.

Nature is uniform. This means that under the same and similar situation, the same things will happen. Nature has an order which continuously and smoothly functions so that every thing happens in an orderly way. However, scientists never assume a general uniformity. They simply assume that there is order in nature and it is intelligible.

The principle of causality says that every event has a cause, and that in identical situations, the same cause will produce the same effect. A cause is a necessary and sufficient condition for the occurrence of an event. However, the exact sciences have done away with the notion of causation. Physical sciences do not seek to discover causal connections.

Science as a Chain of Models

Sciences study inter-relations among facts. Knowledge entails explanation, and explanation is an essential feature of a science. Explanation is implicit in the universe of formal relations as well as in the universe of matters of fact. Explanation is the relationship between different parts or facts of the branch concerned. Sciences try to explain the things in terms of relationship.

Facts appear before us in totality. But at any point of time, we can conceive of a universe of fact i.e., a universe which is empirical in nature along with its relations. Thus, at any point of time the universe of facts appears as a double universe. The two universes (formal and empirical, or universe of facts and universe of relations) are autonomous and independent, but they are complementary to each other. If there is no relation between the two universes the formal universe would be meaningless and the empirical universe would be dark. These two universes comprise formal science and empirical science respectively; and each science has different sub-universes.

The matters of fact in the various empirical sub-universes are not necessarily physical entities, but attributes of entities which could be included in so many sub-universes simultaneously. These common attributes have significant analytical similarities, and form a group of inter-related matters of fact. These common attributes constitute the subject-matter of an empirical science. Sciences can be distinguished according.to their subject-matters. As in the empirical universe there are two broad divisions, namely, physical and social, so correspondingly we have physical and social sciences. Likewise, sciences can be distinguished in terms of method. So far as logical reasoning is concerned, all empirical sciences are fundamentally the same. But since different degrees of ease or difficulty are experienced in the application of principles and processes of inference, on account of nature of subject-matters of sciences, differences in method become inevitable. Over and above the generally accepted principles and processes of inference, different sciences may have to evolve their own special techniques of analysis.

Explanation establishes relationship between facts meaningfully. For the purpose of finding out such relationship, we often have to go to the level of abstraction. At a high level of abstraction, the distinction between formal and empirical sciences gets blurred. At this stage, the deductive structure of an empirical science becomes a mere elaboration of hypothesis.

These relationships between the facts which are used for systematic explanation are called Theories or Models. The objective of every model is the simplification of reality which is essentially complex and perplexing. A model seeks to simplify

reality by isolating the remote and indirect variable factors through abstraction.

Every science can be conceived of as a separate chain of models. It is a chain of models because, being a unified and organic whole, the models in a science must be interlinked. In every science, so to say, there are several sets of models, and every set can be regarded as an envelope covering the models within it. The envelopes of different models are themselves linked together. Since sciences are parts of human knowledge as a whole, and since they are related to one another, they can be conceived of as interlinked envelopes of models.

Order in Science

It is difficult to find out order among facts. However, different people have tried to do so. Bacon is said to have found out an order. Similarly, J.S. Mill has explained order among facts in his methods of experimental enquiry.

The purpose of science is to find the order among facts. Isolated facts do not constitute science. It is generally believed that science aims at finding out, exclusively, a causal order. Various types of order are regarded identical to causal order. A science is interested in finding out the following types of order :

(i) There is a type of order which is so familiar to us that we often forget it. We often give special names to certain things, e.g., air, water, soil etc. Such names are given to these things in order to distinguish them from other such things. The concept of "thing" is a vague concept; however, it denotes an elementary but fundamental type of order. Every "thing" denotes certain invariable association of properties, which is different from other associations of properties. However, this type of order is not causal order. Anyway, this type of order is fundamental to the search for physical order. The classification of things on the basis of our experience can never be complete.

(ii) A type of order which involves temporal span or direction is known as a causal order e.g., "Iron rusts in moist air". Here, moist air is the cause because it produces rusting, which is the effect. A cause is an instance of invariable relation between two or more processes. A causal relation is asymmetrical and temporary in nature. However, the apparent invariability of causal relations is often regarded as specious. Iron does not always rust in moist air. It is not the moist air alone that is the cause of rusting; some other factors are necessary to produce this effect—i.e., rusting. Thus, in developed sciences, a gradual transition takes place from approximate observed uniformities to a more complete analysis of invariant relations.

(iii) With the help of numerical equations, many uniformities

can be expressed. For instance, Ohm's Law of Electricity states that the current is equal to the potential difference divided by resistance. However, this type of invariable relation does not speak anything about the sequence in time, and it is not regarded as an example of causal order. In effect, Ohm's law states that "The measurable elements observed stand to each other in the specified invariable relations."

(iv) There is another type of order among facts where all the elements between which there is an invariable relation, cannot be directly observed or experimented, e.g., the theory of gravitation, or atom. Such theories show that many numerical and qualitative laws can be regarded as the necessary consequences of the more abstract and inclusive order expressed in the theory.

Thus, we see that all these four types of order assert some kind of invariable relation between various types of elements. This invariability is very significant. The search for a cause may be understood as a search for an invariable order between various elements. The exact nature of this order will vary with the nature of the subject-matter and purpose of enquiry. The specific nature of the elements between which order is believed to be existing will also differ for various enquiries. In certain cases, we know the invariable order and some elements, and we may search for further elements. In certain cases, we may come to know the elements first, and then search for an invariable order among facts. In certain other cases, we may know the change, and may look for other changes which are unknown to us.

The type of elements or changes for which we search depends on the structure of the order which interests us. The type of order or the type of elements we search for, is decided by the nature of the problem that gives rise to the enquiry. The answer to one problem is not necessarily the answer to another problem.

Nature and Characteristics of Science

1. A science is a system. It is a system of knowledge where so many facts are related together. It is a system of organised knowledge.
2. A science is empirical in nature. In a science, knowledge is obtained by observation. Verification plays an importat role in science. Verification is based on the facts which we observe and experience.
3. A science is based on critical discrimination. It is objective and impartial.
4. A science deals with the general nature of things and events, and it consists of general explanations and principles.

5. A science is a body of reasoned knowledge. Laws are formulated in a science on the basis of reflection and reasoning.

6. A science is self-corrective in nature. Whenever new facts are found, the old conclusions are revised, if the new facts demand so. It is based on systematic doubt and search for new facts.

7. A science is objective in nature. A science does not depend on subject attitudes like feeling, temperament, bias, etc. A science takes facts as they are in an impartial manner. A science is neutral and free from any prejudice.

8. A science formulates law. Facts are explained with reference to laws. Laws are explained by constructing theories which relate the laws to a coherent system.

9. Another feature of science is its function of prediction. On the basis of laws, a science can predict the happening of certain events.

Value Judgement and Science

Value judgement is regarded as not a part of scientific method. Where value judgements are involved, a science has no method to decide as to which fact is conclusively to be preferred. Thus, value judgement has no place in scientific method. A science is said to be value-free. It is neutral between ends. All ethical judgements and statements which perform recommendatory, persuasive and suggestive functions are value judgements. A science deals with ascertainable facts which are not concerned with value judgements and ethics. A science is objective, whereas a value judgement is subjective. Therefore, value judgement cannot form the subject-matter of a science. If a science is to progress towards objectivity, the influence of personal feeling or bias on experimental result must be minimised. There in no scientific method of testing the validity of certain values—only the consequences may, however, be scientifically known. Sciences can tell us how to achieve goals; it cannot tell as to what goals should be sought.

However, it is stated that a science is based on assumptions that are essentially value judgements.[1] Science itself has developed an ethic base on the assertion that knowledge is superior to ignorance. But these do not impair the objectivity of science; but they rather point out that science has its own metaphysics. Appraisal and selection of problems and motivation behind the selection of science as a career, are value-related aspects of science.[2] But it does not mean that the validity of science is determined by values.

1. Goode and Hatt, *Methods in Social Research*, p. 28.
2. Loc. cit.

In the development of science, the possible sources of subjective bias must be carefully guarded against.

Classification of Sciences

Sciences are classified into the following categories :

Sciences

- Pure and Applied
- Natural and Social
- Positive and Normative

(*i*) *Pure and Applied Sciences* : A pure science is concerned with the search for the truth about different types of events for the purpose of obtaining knowledge. It is not very much concerned with the direct use of such knowledge. It formulates laws and theories and develops a system for the purpose of understanding the subject-matter.

An applied science also gathers knowledge; and it tries to apply practically the obtained knowledge.

These two sciences are closely related—the former is theoretical and the latter is practical. Even, a particular science may have two branches—e.g., Pure Economics and Applied Economics; Pure Mathematics and Applied Mathematics.

(*ii*) *Natural and Social Sciences* : Natural sciences study natural phenomena. Natural sciences are classified into Physical sciences (Physics, Chemistry, etc.) and Biological sciences (Botany and Zoology). Physical sciences study the phenomena concerning non-living matters, whereas Biological sciences study the phenomena concerning living beings.

Social sciences study the phenomena concerning the life of human beings in society—their behaviour, institutions, etc. Social sciences have different branches, e.g., Economics (study of the economic activities of human beings), Political Science (study of the political activities of human beings—political organisation, processes, rights and duties etc.), Sociology (study of social behaviour, organisation and activites), Management (study of a group's business and economic activities) etc.

(iii) *Positive and Normative Sciences* : A Positive science studies facts as they are, i.e., no distortion of fact, or subjective bias is made. It is concerned with the objective truth as given by the facts. Physics, Chemistry, Geology, Astronomy, Biology, etc., are

all positive sciences. Positive sciences are descriptive and objective. The objective of positive sciences is to ascertain a fact as it is and to know the law that governs a phenomenon. The laws of these sciences represent facts that cannot be easily challenged, unless some new evidence or fact develops. The generalisations of these sciences are not influenced by social or individual values or norms.

A Normative science is based on norms or a standard. It sets up norms for the judgement of the phenomena. That is, it makes subjective evaluation or value judgement. It gives judgement as to what is good and what is bad. It studies things as they "should be"—i.e., with reference to a norm or standard. Normative sciences are Ethics, Aesthetics, etc. The norms of the standard in a normative science is based on the conceptions of truth, morality, beauty, goodness, etc. However, these conceptions differ from person to person, from time to time and from society to society. Ethics aims at finding out the nature of goodness of conduct; Aesthetics lays down the standard regarding beauty. The approach of a normative science is evaluative.

Are Social Sciences Normative?

Social sciences are, to some extent, normative, because they are laying down the standard which ought to be attained for increasing human welfare. They are laying down the standard of goodness and badness. Marshall and Pigou have opined that economists have to examine everything from the point of human welfare. Without introducing value judgement, no meaningful proposition in economics can be made, says Samuelson. Economics is not only light-bearing but also fruit-bearing. But Robbins points that economics is neutral between ends and it is not a normative but a positive science. However, it is the function of social science, as Scitovsky remarks, to make value judgements and recommendations on the distribution of welfare.

SCIENCE, ART AND PHILOSOPHY

Science and Art

A science is a systematic body of knowledge. One can study a subject with the help of scientific knowledge regarding the subject-matter. Art is the practical application of the knowledge. A science teaches to know; an art teaches to do. Knowledge necessarily does imply its practical application. A man may have knowledge about electricity, but he may not repair or be able to repair electrical equipments. However, an electrician may very well repair electrical equipments, but he may not be a scholar of electricity—he may not have sufficient theoretical knowledge. An artist depends on practical training and skill, whereas a scientist depends on inference, observation and experiment. Art is creative,

but a science is analytical. Art is qualitative, but a science is quantitative. Art is subjective, but a science is objective. The end-result of the work of an artist is a particular piece of creation; whereas the end-result of the efforts of a scientist is a generalised explanation or law. However, science and art are complementary—science improves art, as art improves science.

Limitations of Science

A science has the following limitations :

1. No scientific classification includes every thing in the subject being classified.
2. Science can discover only that which is discoverable by the techniques available at a particular time.
3. Science follows analysis. Analysis of an object into the simple units is not more real than the whole object.
4. Concepts of beauty and love do not come within the purview of science.
5. Presuppositions of science cannot be verified directly and certainly.
6. Sciences are dependent on man's sense organs and upon his general intellectual equipment.
7. A science is limited also by the limitations of human knowledge.

Some Recent Views on Science

Recently, many scientists have put forward different views on the nature of science. Popper's major work, *The Logic of Scientific Discovery* discusses mainly the features that distinguish science from non-science. He introduced the principle of falsifiability as a criterion of scientific hypothesis. The shift of emphasis from verification to falsification is a fundamental point in Popper's analysis. Popper says that a single refutation is sufficient to overthrow a scientific hypothesis. A careful reading of Popper's work, however, reveals that he was perfectly aware of the so-called principle of tenacity. Popper is a 'sophisticated falsificationist', and not a 'naive' one. He advocates a bold commitment to falsifiable predictions, coupled with a willingness and eagerness to abandon theories that have failed to survive efforts to refute them.

In Kuhn's *Structure of Scientific Revolutions*, the emphasis shifts from normative methodology to positive history. The principle of tenacity is the central issue in Kuhn's explanation of scientific behaviour. Normal science, according to him, is problem-solving activity, whereas revolutionary science is exception in the history of science. For Popper, Science is always in a state of

'Permanent Revolution'. For Kuhn's, the history of science is marked by long periods of steady refinement, interrupted by discontinuous jumps from one ruling *paradigm* to another. The distinctive feature of Kuhn's methodology is not the concept of paradigms but rather that of scientific revolutions. During the period of revolution, there may be some failure of communications. According to him, Normal Science is a self-sustaining and cumulative process of puzzle-solving within the context of a common analytical framework. When normal science breaks down, there appear a number of theories. The new framework offers new solution to the neglected puzzle. The new frame-work continues for a few decades to become a normal science of the next generation. The paradigm changes during scientific revolutions. In the later version, Kuhn pointed out that any period of scientific development is marked by a large number of overlapping and deep paradigms. Some of these cannot be always communicated. The paradigms do not replace each other immediately. The new paradigms emerge after a long period of evolution. Kuhn has deduced his methodology from history instead of criticizing history with the aid of methodology.

Lakatos tries to avoid both Popper's and Kuhn's ideas. In his discussions on *Criticism and the Growth of Knowledge*, he makes a compromise between the aggressive methodologies of Popper and the defensive methodology of Kuhn but his methodology remains mainly within the Popperian camp. He is more inclined to criticize the bad science with the help of good methodology. For Lakatos, methodology has nothing to do with laying down standard procedures for tackling scientific problems. Methodology is concerned with logic of appraisal. It provides criteria for scientific progress. As a normative methodology of science, falsifiability is empirically irrefutable because it is based on *a priori* principles. Lakatos advises the re-examination of the history of science with the help of an explicit falsificationist methodology. He advocates that we should appraise a number of theories which are inter-related (SRP i.e., Scientific Research Programmes). He says that a particular research strategy or SRP is theoretically progres-sive if successive formulations of the programme contain excess empirical content. The SRP is empirically progressive if the excess empirical content is corroborated. According to Lakatos, one SRP is not scientific for all the time. The same SRP may degenerate from progressive to regressive SRP. Thus, we have a historical evolution of ideas over time. Lakatos' theory provides insight as to why some paradigms are replaced by the others. However, a progressive SRP is not always more general than the degenerate SRP. It is evident that Kuhn studies the history of science in order to perfect his normative methodology, whereas Lakatos uses his *a priori* methodology to correct the history of science.

Science and Philosophy

A science is based on empirically verifiable data, but Philosophy is not so. A science studies the material world, but Philosophy studies the material and non-material aspect of the Universe—the real nature of a total phenomenon. A science is based on observation and experiment, but Philosophy is based on speculation and reflection. Philosophy uses critical faculties. Philosophy studies the ultimate nature of existence in general; whereas a science studies a particular aspect or a particular subject-matter. In Philosophy, experience is not empirical, but in science, it is empirical. Philosophy analyses, examines and clarifies the concepts which are assumed by a science. A science is quantitative, but Philosophy is qualitative. A science is not concerned with the purpose of the phenomena, but Philosophy is concerned with the purpose. Philosophy integrates the findings of sciences, and provides the real explanations and tools with which a scientist can investigate into the mysteries of nature. However, science and Philosophy are closely related.

HUMAN KNOWLEDGE

Meaning and Nature of Knowledge

A full discussion of the theory of knowledge is the province of Epistemology. We are discussing here in a most general and limited way the meaning and nature of knowledge.

Knowledge has something to do with knowing. Knowing may be through acquaintance or through the description of the characteristics of certain things. The things with which we can be acquainted are the things of which we are directly aware. Direct awareness may come through perception and sensation. Most of our knowledge of things is by description. Had our knowledge been confined only to acquaintance, we could know really very little. Knowledge by description is strictly personal and individual, and is also probabilistic.

Knowing obviously has an external reference, which may be called a fact. A fact is anything that exists or can be conceived of. A fact is neither true nor false. It is what we know about facts which can be either true or false.

What we claim to know is belief or judgement. But every belief cannot, however, be equated with knowledge, because some of our beliefs, even the true ones, may turn out to be false on verification. Knowledge, therefore, is a matter of degree. However, knowledge need not always be private or individual. Private knowledge may be transformed into public knowledge by the application of certain scientific and common sense procedures. True beliefs can be there without direct perception with reference to facts.

Human knowledge takes the form of beliefs or judgement about a particular phenomenon. Some beliefs may be supported by evidence and some are not. The evidence may be based on our perceptions and experiences. The beliefs which are supported by evidence are called justified beliefs. Only justified beliefs are knowledge. Ordinary belief is not knowledge. Justified beliefs consist of two types of judgements.

(1) Direct or Intuitive judgements

(2) Derived Judgements.

The direct judgements are based on our sense perceptions. Derived judgements are formed out of the existing body of knowledge. This type of knowledge is gathered from the process which, in logic, is known as inference. In this way, from a given judgement, more judgements can be formed. A single direct judgement may lead to a large number of inferences or derived judgements. A large part of our kuowledge is based on derived judgements. Knowledge may be collected from different sources, e.g., experience, human beings, books, Nature, etc.

Knowledge includes what we know about matters of fact as well as the principles and processes of inference. Knowledge has three elements: (i) there is a system of ideas, (ii) the ideas correspond to things actually existing, and (iii) there is belief in such correspondence. Knowledge covers an area where explanation is either not explicitly relevant or just not possible.

However, self-evidence is an essential condition for knowledge, but it is not a sufficient condition, because self-evidence is a matter of degree. Knowledge depends more on ability rather than on possession. The origin of knowledge is empiricism and experience.

Fundamentally knowledge is indivisible; but limited powers of human assimilation and apprehension require that knowledge should be divided and separated. Division of labour and specialisation are causes as well as consequences of the growth of knowledge. Specialisation refines the technique of analysis of knowledge, and discovers new facts and their mutual relationship, and thereby, contributes a good deal to the growth of knowledge. The most important factor in the growth of knowledge is the inherent human curiosity itself.

However, according to some, knowledge is a vague concept for some reasons: (i) meaning of a word is more or less vague except in logic and mathematics, (ii) knowledge is uncertain, and there is no way of deciding as to how much uncertainty makes a belief unworthy to be called knowledge.

Knowing entails explanation. When we come to this stage we have science. When knowledge is applied from a particular world

to the common world, we get the features of scientific theory which unfolds the whole universe of knowledge.

Knowledge and Science

A science is a body of systematic knowledge. All sciences are knowledge, but all knowledge is not science. The following are the differences between knowledge and science:

(i) A science deals with particular knowledge, whereas ordinary men are interested in the whole body of knowledge—to know something about everything.

(ii) Scientific knowledge is unified, organised and systematic, while ordinary knowledge is a jumble of isolated and disconnected facts.

(iii) A science applies special means and methods to render knowledge true and exact, but ordinary knowledge rests on observations which are not methodical.

But scientific knowledge and ordinary knowledge are not different in kind, but only in degree. Scientific knowledge is more specialised, exact and organised than ordinary knowledge.

We have already shown that knowledge requires explanation, and there science comes in. Knowledge and science are not necessarily synonymous. Science implies knowledge, but the converse is not true. Knowledge covers areas where explanation is either not explicitly relevant or just not possible or not contemplated. Explanation is only implicit in the universe of formal relations as well as in the universe of matters of fact. Therefore, logic and pure mathematics are as much science as physical and social sciences. Explanation essentially is the relationship between different parts or facts of the branch concerned.

Even isolated beliefs can fall under knowledge. But only those beliefs which have some sort of affinity or interconnection can fall in a particular universe of science. Unlike in knowledge, in science, explanation is always found relevant, necessary and explicit.

In so far as the various sciences are not unrelated to one another wholly, they form parts of human knowledge as a whole, and all sciences can be conceived of as inter-linked envelopes of models. It is this interlink which distinguishes science from ordinary knowledge. A systematic body of knowledge only can be called a science.

Scientific Knowledge

Scientific knowledge is organised factual knowledge arrived at by the use of Scientific technique and methods. Such knowledge

is verifiable, objective and universal. Scientific knowledge cannot be absolutely certain. It is only a probable knowledge. It is self-corrective in nature. Common sense is non-scientific. Either subject-matter, methods or both should be considered for distinguishing scientific from non-scientific knowledge. There are mainly four theories about the nature and status of scientific knowledge. These theories are : (1) Complete phenomenalism (2) Fictionalism, (3) Scepticism, and (4) Realism.

According to complete phenomenalism, only the observed phenomena become knowledge. Thus, a science is concerned with the identification, classification and relation of phenomena. Phenomena can be ordinarily perceived or it can be had after analysis. In the sense of the first form of complete phenomenalism, we cannot rely on the hypothesis which goes beyond the facts of observation. In a science, whatever cannot be perceived, cannot exist. On the basis of past experience, we formulate the scientific theory and the laws of nature. According to Mach, *Law of Nature* is nothing but the record of our past experience. Unless we have the knowledge of element or sensation, we cannot have the knowledge of things. Bridgman thinks that the operations in the laboratory are ultimate phenomena. However, operations may not always lead to scientific knowledge. According to Eddington, the fundamental phenomena are nothing but numerical readings of the scales. He regards the measure as the phenomena. But such a notion can always be criticized.

According to the theory of Fictionalism, all theories are fictions. This view is the result of crisis in science when there are many theories in a particular problem; and when nothing can be resolved, they look like fiction. Therefore, fictionalism arises out of confusion and crisis.

The Sceptics regard theories as neither true nor false. The theories are simply the instruments of research. This idea is called instrumentalism.

The three theories discusssed earlier, are based on non-Realism. Non-realist theories cannnot explain some phenomena. According to the theories of Realism, the existence of real things is capable of demonstration and proof under certain given conditions.

Appendix

STOCKS AND FLOWS OF KNOWLEDGE

In a recent article in *Kyklos*, F. Machlup[1] has tried to build

1. Fritz Machlup, "Stocks and Flows of Knowledge" *Kyklos*, Vol. 32 (1979) 1/2. pp. 400-411.

up a conceptual frame-work for analysing the stock and flow of knowledge. He aptly remarks that any attempt to quantify knowledge has had many limitations. Obviously his is a conceptual exercise in which a few comments can perhaps be accommodated to clarify and extend his conceptualisation.

A proper definition of knowledge is essential before one attempts to measure its stock and flow, for knowledge may have different components or may be of different types, e.g., subjective and objective, material and non-material, productive and unproductive, systematic and unsystematic, applied and theoretical, or it may be any information, fact, belief or judgement. In fact, differences in conceptualisation will lead to different estimates of stocks and flows.

Machlup has mainly based his discussion on Price's theory for estimating the stock of recorded knowledge, on Gore's and scientometricians' studies for discussing the role of books and on phenomenological theory for estimating the knowledge of the human mind. All these studies have their own limitations and they conceal more than what they reveal. His attempt at "estimating the stock of recorded knowledge" and "estimating the flow of knowledge" is abortive, for these do not give any precise estimates. Strictly speaking, the stockflow analysis should be in terms of some measurable units. Knowledge being an intensive quality, having no meaningful unit, cannot be estimated in stock-flow terms. Of course, one can always vaguely describe any accumulation as the stock and its distribution as the flow upto a reasonable limit. What Machlup calls 'flow' is perhaps the transmission of knowledge.

Among recorded knowledge, he has included only published material. What about the unpublished or non-marketed papers? The scientometricians observe that growth of knowledge is more meaningfully estimated by the number of articles in scientific journals rather than by the number of books (p. 401). This statement does not appear to be correct for the following reasons: (i) there may be original research books in any discipline, and (ii) even literary and other journals substantially advance knowledge. There may be possibility of duplication and the growth of same knowledge (findings) by different methodologies. The last point is particularly true with respect to the so-called scientific journals in low-developed countries (LDCs).

The categorisation of scientific journals is sometimes arbitrarily made. Many existing journals in the world are scholarly journals without being scientific or technological. Many renowned scholars/scientists have been writing in very ordinary journals. According to Machlup, the question regarding the equivalence or otherwise between short and long articles become irrelevant if their ratio remains more or less constant over time (p. 401). These

ratios, needless to say, do not reflect anything about the stock of recorded knowledge. So far as the growth of knowledge is concerned, a paper of volume is not to be judged by the quantity of materials it contains but by its quality, originality and the spirit of innovation it generates. From the point of view of growth of knowledge, an entire volume may be useless, but a single issue or paper may be very valuable. It is worthwhile to distinguish between ordinary articles and research papers, the former very often represents assimilation from the existing recorded knowledge and does not contribute anything to the growth of new stock of knowledge. In view of all these, it is difficult to agree with Machlup's observation that the simple estimate of a stock of knowledge would be in terms of volume (p. 401). We may get a better estimate of the growth of the stock of knowledge by eliminating reproduced papers, ordinary assimilated articles and duplicate records from the total volume of publication.

The calculation of the exact number of journals published in the universe is a tedious physical job. Price's calculation of the number of journals published in a period of time on which the author relies is not very helpful, once we adhere to the notion of the growth of stock of knowledge over time. 5 per cent annual rate of growth of population of journals is arbitrary. What is more crucial is the net rate of growth of journals (birth rate minus mortality). In his attempt to estimate the stock of growth of knowledge, he considers only the journals of natural sciences, mathematics and technology (p. 403). One wonders why he is constrained to exclude arts subjects and social sciences.

He opines that books matter in humanities and social sciences. Why should one not take into consideration research journals in these fields? Do the books not matter in natural sciences, technology and mathematics? Machlup reports that in the USA, the combined library collection of books in 1975 contained nearly 9 million titles (p. 404). Apparently, library books contain reference books, text-books and pure research books. Many books contain the same theories and knowledge; the explanatory style, languages or wordings may, of course, be different. Unless such duplicate works are eliminated, mere counting of number of titles would be a futile exercise.

As Machlup observes, the knowledge of the living people is the relevant social stock of knowledge (p. 405). On the basis of their differences in skill, education and training, different people will have different stock of knowledge. As such, recorded knowledge remaining fixed, there would be differences in knowledgeability. It should, however, be borne in mind that the stock of knowledge is a function of many factors, e.g., capacity to know, willingness to know, and facilities to know. These factors will have their effects on the stock of human knowledge. To appreciate the stock of knowledge in the human mind, it is necessary to

classify human beings and observe their essential differences, as in the following chart which is self-explanatory.

	Attributes/Manpower Category	Illiterate	Fairly Literate	Highly Qualified
1.	Basic Low-level Common Knowledge	Equal	Equal	Equal
2.	Absorptive Capacity or Power of Assimilation	Very Low	Low	High
3.	Actual or Potential Contribution to Knowledge	Nil	Low	High
4.	Possibility of Extending Scope of Knowledge	Very Limited	Limited	Large

Machlup has not considered it necessary to distinguish between social stock of knowledge (SK) and private stock of knowledge (PK) on the basis of any criterion (though it is necessary) nor has he made any distinction between subjective (s) and objective (o) knowledge. In a very general but meaningful sense, social stock of knowledge is more organised and objective (o) and is in the nature of a public good, whereas private stock of knowledge is more subjective (s) and is in the nature of a private good. Once one is permitted to make this distinction, the following four possible situations emerge:

$$SK_s > PK_s \quad \ldots\ldots\ldots\ldots \text{(i)}$$

$$SK_o > PK_o \quad \ldots\ldots\ldots\ldots \text{(ii)}$$

$$(SK_s+SK_o) > (PK_s+PK_o) \ldots\ldots\ldots\ldots \text{(iii)}$$

$$(SK_s+SK_o) = (PK_s+PK_o) \ldots\ldots\ldots\ldots \text{(iv)}$$

The above four cases can be considered to be true in different situations. It is too much to accept Schutz/Luckmann's view (p. 406) that social stock may be less than any particular subjective knowledge. The biographical uniqueness of experience and other unusual elements of a particular person may also be present in a greater degree in the social stock of knowledge in terms of subjects, theories and informations. However, it has to be noted that scientific knowledge is not the sum of all knowledge, for some knowledge remains always unorganised. Subjective knowledge is basically incomplete and imperfect. In order to make it objective it has to be properly processed and systematised. However, the social stock of subjective knowledge, provided the latter possesses some hitherto unknown knowledge over and above knowing the

entire social stock of knowledge (both subjective and objective), is a very heroic assumption to make. Social knowledge should be used in net sense, whereas private knowledge can more appropriately be the gross one.

A society may be looked upon as a different type of individual. The introduction of a new knowledge will at once increase the social stock of knowledge, but it may not increase the private stock as a whole, albeit at least one person who has made the innovation will have increased his stock. All private stock of knowledge will increase the social stock, but the *vice versa* may not be obviously true, for there are various constraints to the flow of knowledge. Social knowledge cannot be considered to be equal to the sum total of private knowledge: their component ratios are different. Thus, our case (iv) earlier may not be strictly valid. The theory of cybernetics has increased SK, but even if this knowledge is imparted to several million people, the social stock will remain the same; what will increase is the PK. Machlup has posed the following two questions regarding the spread of knowledge: (a) more people may be imparted the same knowledge, (b) same people may be imparted more knowledge. Both will raise private stock of knowledge and both are necessary, but a choice has to be made between the first which can be called extensive or basic education, and the second which may be called intensive or specialised education. While the first type is more suitable for a low developed illiterate society, the second type is essential for a developed and educated society.

According to Machlup, the problem of quantification of the flow of knowledge can be avoided by assuming that all newly recorded knowledge is read and absorbed at least by one person (p. 408). Firstly, this assumption is obviously unrealistic, and even if it is presumed to be valid, how will that avoid the quantification problem *per se*? The scientometricians' attempt to measure the flow of recorded knowledge in terms of physical units is not at all correct. What is the unit and how can one find a successful criterion for calling a bit of knowledge as one unit? The whole state of affairs is a horrible mess of misconception. The author assures that in some areas of knowledge transmission, it is possible to count physical units. Instead of telling us how to find out the physical units, he advises to note the differences in volumes, library materials, numbers and sizes and so on relating to knowledge media. But this does not solve the problem of finding out the appropriate unit. What he precisely speaks of (p. 409, para first) is the speed of work, and the efficiency of different communication systems, and not about the measurement of knowledge as such.

Machlup believes that expenditure incurred or revenues collected, expressed in monetary units on education, can be regarded

as a measure of the flow of knowledge (p. 409). We may purchase more books, equipments or gadgets, but do these by themselves guarantee the increased flow of knowledge? However, the growth of social knowledge can partly be known by the degree of advancement of technology or the improved vintage, which can be gauged by comparing the old and the new cost-benefit estimates. For a society, cost incurred on old knowledge will not increase the stock, but only the production of new knowledge will enlarge the stock. Expenditure even on research may not always lead to the dissemination of knowledge. Although it provides a new insight into the existing stock of knowledge, it may lead to duplication of results already known to the society. Returns are proportionate to the scale, but the cost of knowledge may be very often scale-free. Thus, cost cannot be meaningfully related either to stock or to flow of knowledge.

In Machlup's conceptualisation, the flow of knowledge may be of five categories, accumulation, replacement, current input, consumption or waste or any combination of these factors. One can also conceptually consider knowledge as a future (potential) input helping production later on. What the author has overlooked is the fact that such a classification is not only relevant to the flow but to the stock of knowledge as well. Accumulation, to him, is the flow which makes a net addition to the social stock of knowledge. Why can it not be considered to be a net addition to the private stock of knowledge? Ordinarily, a flow of knowledge, more often than not, does not lead to social accumulation but to private accumulation. This point has been missed by the author. Machlup speaks of the replacement of that part of the stock of knowledge which has been forgotten, wiped out by death, or has become obsolete. We must remember that in the case of recorded or already transmitted knowledge the question of replacement becomes less important. The crucial question is : how far can knowledge be considered to be obsolete or waste ? None can be sure. What is the mechanism to determine whether a particular piece of knowledge is forgotton, obsolete or waste? What may appear to be obsolete or a waste today, may appear to be very new and useful tomorrow under a different value system, time horizon and social structure. One of the ideal examples, is the recent revival of the Yoga system and natural therapy in most of the Eastern countries today. Again, what is useful in one type of society may be useless or even harmful in another system. Many will believe that borrowed technology or western growth models cannot be profitably employed in LDCs. If wastage is involved everywhere, it should not be taken as an exclusive category as the author makes it to be.

Machlup has attributed waste to both flow and stock. The statement: "virtually every flow of knowledge may have an admixture of waste, some efforts of producing knowledge proving

either abortive or superfluous" is a *non-sequitur*. He has mixed up in connection with 'waste', flow and stock which form entirely two different categories of concepts. To calculate wastage through the cost benefit approach which the author has in mind (p. 411) one has to employ monetary terms. But knowledge being what it is, no monetary calculation of waste appears to be feasible. We can, at the most, say which technique is better without, perhaps, quantifying the wastage involved. The cost remaining the same, one technique may prove monetarily gainful; and the gain or result remaining constant, a high-cost technique does involve some comparative material loss. But it is preposterous to call it wastage of the flow of knowledge. In fact, every flow of knowledge is associated with an opportunity cost. Knowledge can be regarded as waste or unproductive if that opportunity cost cannot be covered. But how does one know at the moment that the opportunity cost cannot be covered even in the long run? As the proverb goes : knowledge is power, and knowledge is its own reward. It always equips man with the ability to differentiate between good and bad, pure and impure, right and wrong. Considered this way, knowledge is never wasted. As a matter of fact, knowledge even faces diminishing marginal utility in terms of the material fruit it generates; but it is far from useless. Knowledge is not merely a fruit of contemplation, but an instrument of change as well.

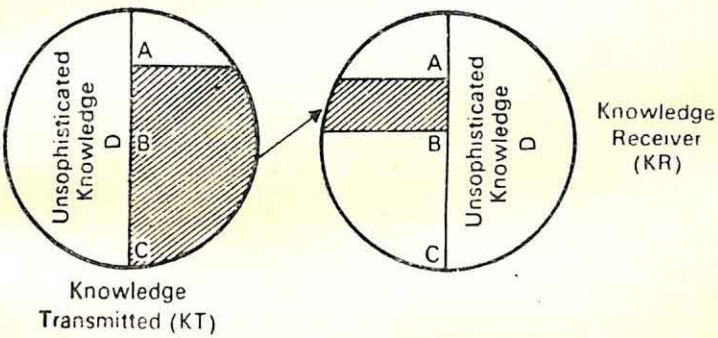
One indeed has to be very cautious to consider a particular flow of knowledge as "current input". How can one ensure that it will help only current production and not the future one? In the area of production, current and old technologies are in symbiotic relation. In reality, it is very hard to specify an input which will be currently used and not in the future. Of course, if its life-span is shorter, it can be reproduced with the same stock of knowledge. However, if the rate of technical change is very high, the rate of obsolescence also goes up, and less relevant becomes the current flow or even the stock. In computing the stock of knowledge as a current input, a steady rate of technical change can be constructed as a discount factor for past experience. The discount may work forward to reduce the current knowledge for future use. Investment in knowledge for future use may be uncertain, and unless the technology of learning is specified, any generalisation in this context is unwarranted.

The flow of knowledge can be, Machlup maintains, "consumption" if it helps current enjoyment (p. 410). Why does he exclude future enjoyment? The same flow of knowledge may be a perennial source of enjoyment both at present and in future. The conceptual problems that arise are the following: (i) same flow may be a consumption good to one but may not be so for others (ii) same flow may be a consumption good to one at a particular moment of time, but may not be so at another time. It is indeed very difficult to find out the analytical basis of the entire

classificatory scheme which Machlup has made.

A word about the input-output and stock-flow aspects of knowledge. The same knowledge may be either input or output, or stock or flow, depending on the time, use, circumstances and the purpose. When some knowledge is discovered and is immediately transmitted, it can be both a stock and a flow. In the case of contradictory theories or empirical findings, it becomes a formidable task to tell precisely about the stock position. Machlup's net stock of knowledge (accumulation) is the gross stock minus replacement. But what is the mechanism to ensure that a particular flow is gross or net? When a research result is published, it becomes a recorded stock; but in the process of publication, it becomes a flow. A stock is already a flow and, vice versa. Thus, the distinction between the stock and flow of knowledge cannot be specified in clear-cut, applepie order.

Indeed, there is a big chasm between stock and the flow of knowledge. According to Machlup, the efforts at disseminating knowledge may be either due to the fault of the transmitter or of the receiver (p. 411). In fact, it may be due to the fault of both, or may not be anybody's fault. There are various constraints in the transfer of knowledge, some of which may be due to the peculiar social system. There may be socio-cultural inhibitions to transfer knowledge. The qualitative or conceptual knowledge may be described only in terms of the concepts that the receiver is already familiar with. Without taking into account the technique used, the real measurement of the effective flow of knowledge is impossible. The different possible levels of flow of knowledge between the transmitter and the receiver can be explained by the following diagram.



In Fig. A, the individual universe of knowledge is divided into two parts—unsophisticated (D) and sophisticated (A, B, C). A is more sophisticated than B, and B is more sophisticated than C. Area A may be the unattainable absolute area of knowledge.

We can conceive of the following three situations between K_t and K_r.

$$K_t > K_r \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

(As in the diagram)

$$K_t = K_r \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$K_t < K_r \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Of these three situations, the third situation is conceptually impossible. Second situation may be called the optimum level of flow. The optimum level is not, however, a permanent and stable level; it may change into non-optimum ($K_t \quad K_r$), or the non-optimum situation may gradually be one of optimum. There can be no flow of knowledge which is higher than the highest level of sophistication achieved by the transmitter and the receiver. Any amount of pretence does not lead to any effective flow of knowledge, and sometimes it is difficult to know what we do not understand. In such a situation, there is no question of flow of knowledge. Language barrier is another factor inhibiting the effective flow of knowledge. Moreover, the knowledge of super-expert cannot very often be effectively transmitted to a layman. In fact, much is leaked out of the stream of knowledge in the process of its flow. Thus, flow cannot be made amenable to precise measurement. No analysis of stock and flow of knowledge can be made objectively rigorous especially when the stock and flow cannot be quantified. Even after accepting this truth, Machlup explicitly ventures to estimate the stock and flow of knowledge.

2

METHODS IN SCIENCE : NATURE AND TYPE

Nature of Science Determines Methodology (Role of Method)

Sciences, as a whole, lay greater emphasis on method than on result. A method is the way of approaching the problem. In order to find out the truth involved in a problem certain steps must be taken in certain order, and the ordered steps are called a method. If a science follows a wrong method, the systematic knowledge or the truth cannot be ultimately found out. Thus, the use of a correct methodology in science is very essential, because, unless the right methodology is followed, thoughts cannot be arranged in correct order. As a result, the exact truth can neither be discovered nor be exposed. Methodology stands for "the correct arrangement of thoughts either for the discovery or for the exposition of truth." A correct methodology is required for arriving at a correct or an exact knowledge which a science wants to establish. The consistency of thought cannot be attained by means of inconsistent set of reasonings or method. Whether a science is inductive or deductive, a correct methodology is always necessary.

In every science, the methodoloy, technique or device is relative to the problem. The type of steps to be applied will depend on the end that is sought to be achieved. Methods and techniques are not ends in themselves; but they are necessary to comprehend and interpret problems. The operative value of a method is related not only to the problem which is being analysed, but also to the alternative tools that may become useful in course of the analysis. Every method has its utility in the proper situation, and no methodology is by itself superior to another. Where one method is applied to find out the result, others can be used to verify the conclusions obtained. Prof. Northrop[1] observes that there are as many different scientific methods as there are different kinds of problems. He opines that different stages of enquiry

1. F.S.G. Northrop, *The Logic of the Sciences and Humanities*, p. 30.

have different scientific methods, and that a method which is scientific at one stage may not be scientific at another stage. Scientific method, like time and space, is relative to the stage of enquiry and the type of problem. In fact there are several types of rational methods and several types of sciences.[2] The appropriate method to be applied in a science is determined by the nature of the science. A method in science is highly elastic and adjusts itself to new problems as they arise.[3] Different types of sciences study different problems and aim at discovering different types of laws.

The method which is to be adopted in a scientific enquiry, therefore, is partly determined by the subject-matter of study and partly by the end or purpose of study i.e., the objective. The deductive sciences start from universal or general propositions and arrive at a particular or specific proposition. Inductive sciences start from particular and specific cases and arrive at general or universal propositions or laws. The analytical or experimental method is generally applied to a science which deals with concrete facts and instances; but as this science becomes more and more progressive, it makes use of deductive or synthetic method. For instance, to start with, physics was an experimental science using inductive methodology, but through evolution at various stages, physics has now become more and more deductive in nature, because it is amenable to exact quantitative measurement. Pure physics can, therefore, be regarded as quite akin to a deductive science like mathematics. The scope or the possibility of quantitative measurement in a science becomes one of the most decisive factors for determining its methodology. When an empirical or experimental science becomes amenable to exact quantitative measurement, it no longer remains empirical, but becomes mainly a deductive science. For instance, mathematics, pure physics, astronomy, etc., are deductive or synthetic sciences, whereas geology, chemistry, etc., remain inductive, experimental or analytic.

It is, therefore, clear that since the nature and objective of sciences differ, the methodologies have got to be different. Sciences like physics and chemistry depend upon controlled experiments, andsciences like astronomy depend on observation and calculation. Since human behaviour cannot be subjected to controlled experiment and observation, the social sciences usually follow a sort of inductive method where quantitative measurement cannot be applied with precision. In social sciences, therefore, trial and error, sampling and statistical methods are sought to be applied with as much accuracy as is possible. Thus, depending on the nature of the material or the problem under the consideration of a scientific study, the proper methodology has to be framed. In social

2. See, Litt and Caldin's View in *Science and Freedom*, 1955, pp. 141-150.
3. Marganan, *Science and Freedom* (Proceedings), p. 148.

sciences, in general, the research becomes either problem-oriented or method-oriented. But in every case, it is almost a general truth that the nature of science determines its methodology. This statement may be substantiated by discussing the nature of some of the sciences and their methodologies.

Some Sciences and their Methodologies

The objective of physical sciences is to unfold the mysteries of the inorganic world. They deal with and try to understand the organic world. Physical sciences are classified into the mechanical and the chemical. Physical sciences use physical methods in which deduction precedes induction. According to this method deductions are first made from certain suppositions and then empirical verification is made. Thus, these sciences are analytic mainly, but they also take the help of synthesis.

The natural sciences progress by studying the process of evolution of living beings. The principle of natural selection and the principle of heredity have not been accepted without controversy. In natural sciences mere analytical methodology is not enough. They require more threadbare analysis and thorough study of facts. The explanation of the process of evolution of living beings requires the help of mental construction and reconstruction. Natural sciences, e.g., biology, are still in their infancy, and have to go a long way before they can attain perfection.

Mathematics is purely a deductive science. It is not concerned with the facts of Nature and their relationship. Mathematics is based on axioms, definitions and proof. In mathematics, conclusions can be arrived at from self-evident propositions or principles. Mathematics, which is a deductive system, is concerned with working out the implications of propositions. Thus, in mathematics, the methodology is synthetic.

The historical sciences study the thoughts, actions and reactions of human beings. History cannot make use of observation or experiment. History requires the reconstruction of historical events, and in this mental construction, objective reference becomes essential. In history, classification, weighing of testimony, examination, explanation and formation of plausible hypothesis have to be done. The hypothesis can sometimes be verified by witnesses, other evidence and record. But in the act of mental reconstruction, good bits of subjective factors creep in. History takes the help of both deduction and induction. In historical method, induction precedes deduction. In history, empirical generalisations are first made, and then an attempt is made to derive them from other laws. The analytic method is used in history, since something is tried to be discovered; and since a great deal of exposition is required to synthesize the results, history has also to make use of synthetic method.

Social sciences, to a great extent, are historical. In social sciences like economics, political science, etc., experiment and observation cannot be completely carried out. However, the social sciences are still following inductive method, such as, the building up of hypothesis and limited observation and experiment. In social sciences, particularly in economics, analytical studies are considered to be more important for empirical research. Empiricism becomes meaningless unless it is guided by some principle, theory or analysis. For analytical work empirical study is important for many reasons. The empirical generalisations can examine the validity or otherwise of both the assumptions and implications of an analytical work. The empirical generalisation can become the basis for analytical works.

In biology and social sciences, comparative method is generally applied. This method is useful for studying continuity and development. This method is also applied in social anthropology. This method suggests an explanatory hypothesis which can be developed by means of logical deductions. In comparative method, the irrelevant conditions are eliminated. This method is used to show that social institutions, like biological species, continuously evolve and pass through different stages. The stages represent temporal sequence. This method works through the study of comparative anatomy. Thus, it is clear that different sciences try to evolve methodologies which are relevant to their subject-matter and nature.

Analytic and Synthetic Methods

Analysis means the breaking up of a thing into its constituent elements. What is analysed is complex as compared to the elements which are simple. Analysis has to be made in order to know the cause or the effect of a complex phenomenon. Analysis can determine which elements are relevant and which are irrelevant. Analysis is the process of breaking a whole into its elements. The analytic method is called the method of discovery. The analysis may be either physical or mental. When a physical phenomenon is analysed into its different elements, the analysis is known as physical analysis. But when the particular aspect of a human being is analysed into its constituent factors, the analysis is called the mental analysis. In physical analysis, the factors are physically separated. But in mental analysis, the factors are only mentally analysed and separated. Analysis is only a method used to arrive at the truth of a phenomenon. But since it is a method, it is not an end in itself. Scientific analysis does not identify an object with the elements that constitute the object.

A synthesis is sometimes regarded as the reverse of analysis. A Synthetic method is called the method of exposition. Synthesis is the process of combination of parts into a whole. A system in a

science implies the relating together of things in certain order. Since synthesis means the relating together of things, it can be considered as the fundamental aspect of a science. From the point of view of logic synthesis starts from the simplest thoughts or notions, which are ultimately united and related together. Geometry provides the best example of logical synthesis. When we say that the three angles of a triangle are equal to two right-angles, we are, in fact, making a logical synthesis. However, in geometry we very often use analysis also when we try to separate and identify the different properties of a figure. In natural sciences, a distinction between analytic and synthetic methods can be found out. A natural phenomenon can be considered with respect to its constituent elements, and, at the same time, different elements and their properties can be related together to fully explain a natural phenomenon. In induction, one is making use of analysis but in deduction, one is making use of reasoning which is synthetic in nature.

New truths may possibly be discovered also by synthesis and the old truths may be explained by analysis. The same science sometimes may be explained by analytic method and sometimes by the synthetic method. For instance, Prof. Herschel explains astronomy partially through analytic method; but Prof. Norman Lockyer explains astronomy through synthetic method. However, for a fuller understanding of things and for the progress of scientific knowledge, a combination of synthetic and analytic methods is urgently required. Both are equally fundamental to scientific knowledge and to the discovery of order in Nature which is the foundation of every science. Some phenomena are essentially complex. They are understood by means of simplification through the analysis of their component elements. Analysis is helpful for making meaningful comparisons. After the analysis is made, the relevant facts are separated out and related together in order to find out a general law.

Both analysis and synthesis are explanatory methods. They are helpful for our understanding of things and their relations. Through the help of synthesis, one can study the properties of the compound from the properties of constituent elements. Synthetic thinking is made possible by analytic thinking. The two are interdependent. In every science, they are used jointly, although in some sciences synthesis is more important than analysis, and in some others, analysis is more important than synthesis. The formulation of a law works in the direction of evolving a synthesis that makes use of analysis. The formulation of the concept of a class is considerably helped by synthesis on the basis of analysis.

At the initial stage of a science, analysis plays a more important role than synthesis. And as the science becomes more and more progressive, synthesis plays a more and more important role.

But in every science both the methods are used simultaneously. The objective of analysis is to test hypothesis. Analytic and synthetic methods jointly work to arrive at the truth in a more convincing manner. The nature of the science determines the appropriateness of the synthetic or analytic method. When the subject-matter is highly abstract and the relations are formal, synthesis plays a more important role than analysis. But when the subject-matter is less abstract and does not admit of exact quantitative measurement, and the relations are informal, analysis plays a more important role than synthesis. Thus, in pure mathematics, the method is purely synthetic; and in chemistry, biology etc., the method is analytic. But even in pure mathematics, analysis is used in the explanation of the conditions of the theorems. Similarly, in psychology and biology, synthetic method cannot be given up. In order to reveal the complete picture of different forms of life in the organic world and the mental functions as the necessary correlatives of the nature of consciousness, the synthetic method is of much help.

A science aims at not only arriving at the truth but also at expounding the truth. A synthetic method is necessarily expository because it puts together the elements of a phenomenon in a systematic manner. In synthesis, exposition is possible because the entire elements are completely known and, as such, they can easily be arranged in an orderly way. The discovery of truth, however, is made possible by the method of analysis.

The inspiration of the scientist is one of the determinants of the part played by analysis and synthesis in scientific investigations. Some people have thoroughly searching minds and skill to find out the correct type of relations between things as compared to others who are devoid of such powers. In natural science, Darwin was such a genius. Similarly, J.C. Maxwell was efficient enough to predict a synthesis between the science of optics and the science of electro-dynamics. But, for these outstanding people, analysis also became necessary. Newton was a scientist who primarily made use of the analytic method and who, due to his deep insight, was also able to unfold the involved synthesis. Thus, synthesis and analysis are the two legs on which the entire body of systematic knowledge of a science stands.

Methods of Social Science

Various methods, e.g., historical method, comparative method, descriptive method, scientific method, survey and field research method, institutional method, conceptual method, etc., have been applied to social science research. The first four methods are very interesting, and here we shall confine our discussions only to these methods.

HISTORICAL METHOD

Significance

In a social science like economics, historical method found its expression and application as early as in the middle of the 19th century through the writings of the German Historical School. Past knowledge is considered to be pre-requisite for present knowledge. This is the main argument for the adoption of historical method in present-day social research. Nothing happens in a social vacuum. In so far as anything has an anticipated history and natural development, past is causally related to the present. Although there is inter-temporal change of situations, there are still certain orders and regularity in social matrix. These regularities are regarded as process-series sequence-pattern periodicities and cycles. It is said that history repeats itself. This, though not wholly true, is broadly valid for social phenomena. In order to appreciate these regularities and social influences, one has to resort to the historical method. Historical method is "the induction of principles through research into the past and social forces which have shaped the present."[4] In order to discover some basis for social activity, the method becomes genetic in character. The main objective of this method is to apply mind in the matter of various social problems by discovering the past trend regarding facts, events and attitudes, and by demarcating the lines of development of thought and action.

History and sociology are, in a sense, the two sides of the same coin. "When our attention is directed towards the uniqueness, the individuality of past social facts, when they interest us because of their importance for the unique evolution of man in his activities as a social being, in selecting the facts and in grouping them into a complex, evolving whole, we employ the historical method. . . We select our facts, not for their individuality or for the importance of their individuality for a complex whole but for what each fact has in common with others and the synthesis is not a common complex unique whole but a generalisation in which no trace of the individuality of the past social facts remains. . . Thus the work of the historian supplements that of the sociologists. The historian is interested in the quantity, in generalisation, in repetition."[5] A social researcher can only neglect history at the cost of great risk.

Essential Requirements for Application

History is the product of circumstances and environment. Therefore, unless the environment is known, historical facts and data cannot be fruitfully applied. To begin with, a good deal of social insight and historical orientation is necessary. Social insight,

4. P. Young, *Scientific Social Surveys and Research*, p. 207.
5. F.M. Fling, *The Writing of History—An Introduction to Historical Method.*

which implies studying of data with reference to environment, is necessary to bring about causal relations. The researcher adopting the historical method must study the cause and effects relations of historical events. The historical method requires experience not only in collecting data but also in finding out their relations and significance in the particular context. Since an environment is the product of different factors—economic, political, sociological etc.,—a researcher has to have knowledge of these disciplines.

History is a phase of social life. A researcher, must take up the analytical view in order to get perfect control over facts and the synthetic view of facts. He should be able to find out the relations between events and events, and between events and environment. It is necessary to make an objective approach both in discovering facts and interpreting them. But in order to be objective, the approach must be based on relevant, adequate and reliable data.

For applying historical method, the researcher should be familiar with the general field of his topic and be clear with regard to his own objective. A good deal of imagination, is required to apply the historical method. Without imagination, history would produce disjointed and meaningless collection of data.

Probable Inference in History[6]

The statement that the present can be understood only with reference to the past is, however, not true. The nature of things must be known first, before the study of the things from the past takes place. Knowledge of history can be achieved only through inference, the premises of which can be obtained by scrutinising the present material whose evidential value is determined by hypothesis which itself can be tested by current events. Knowledge of the past has no exclusive priority over the present. All this, then, points out that scientific method is also required in history. Historical evidence is never complete and conclusive and, therefore, the conclusion arising out of it is only probable. In history, hypothesis is necessary either to fill out the scanty material with suggestions of relation where it is absent, or to select the most significant fact out of plenty. However, the determination of the meaning of historical data must be roundabout. This is because the historian's witness can be questioned and made to answer. In so many cases, the truth of a historical proposition may not only be substantiated by independent witnesses, but also be verified by the calculable consequence which a past event has generated in the present. Historical propositions may also be conformed by the principles of social behaviour and natural sciences. Historical propositions should be so arranged as to form a coherent whole. Systematic theories to explain history are indeed essential. However, perfectly comprehensive theory, perhaps, cannot be achieved in human history. The

6. Cohen and Nagel, op. cit., pp. 323-344.

theories of human history cannot be as perfect as those of natural sciences because of the complicated factors and subject-matter of the former. They cannot be interpreted in deductive fashion and are, therefore, not capable of refutation and verification. Inferred historical facts are very deceptive, since there is no possibility of discovering the possible error. However, it cannot be denied that the present contains the past, because the consequences of the past are inherent in the present. The present is always merging into the past and past events are considered in the light of consequences they lead to. The responsibility of history cannot cease so long as events lead to consequences.

Limitations

For the successful application of the historical method, reliable and adequate data are required. The deeper is the past, the greater is the difficulty of obtaining the relevant facts. Secondly, the records are not always kept in order. Therefore, the researcher needs a great deal of patience to find out accurately his facts and materials. The documents are too dispersed, and all the data cannot be had from one institution only. Another limitation relates to the fact that the data have to be taken into the frame of the conditioning phenomena, otherwise their real significance would be lost. The follow-up of the conditioning phenomena is difficult because of the time-lag between the phenomena studied and the present situation. The determination of the exact nature of the past phenomena is not an easy task. By the very nature of historical procedure, it is not always possible to refute and verify the historical data and thereby their inferences. Thus, scientific method, in its entirety, cannot be applied in the case of historical method.

In historical method, calculation and measurement, as in quantitative method, are not possible. Thus, great caution has to be taken for the collection and interpretation of such data. The available historical records may be selective and may contain the subjective bias of the author. These may overestimate the events of secondary importance. However, the danger of selectivity is very great, since the observations are made very often by persons untrained in research.

Steps for the Application of the Method

Firstly, the choice of the exact problem is essential. Every problem is not amenable to historical research. The problem should be worthy of investigation in itself. The researcher in this field should be experienced and highly trained. Since the collection of data requires considerable time, the subject of investigation must be related to the time at the disposal of the researching hand. Pursuing of historical method involves, obviously, huge expenditure which every researcher cannot afford. Secondly, the important step is the

collection of data. The relevant information is to be found out next by looking into the sources—both published and unpublished. The next task is to ascertain as to which are the official documents and which are not. One should study the published secondary literature related to the field of investigation. This would be helpful in finding out the correct sources. The third step is to study all the available material on the subject. If this is not done, the research becomes biased, incomplete and partial. While collecting, the data should be classified into primary, secondary and tertiary sources and be evaluated in terms of the source. Documents are helpful for the verification of certain events and in finding out the missing links in the social institution. But the documents themselves should be subjected to verification and test in order to prove their authenticity.

The Use of Documents

The nearer in time a document is to the period under investigation, the more believable it is likely to be, in general. Similarly, the more detailed the information, the more reliable it is. Official documents are to be preferred to the private documents. The greater the agreement between various records, the greater is the probability of the data being correct. Personal accounts and records are mostly subjective and, as such, they should be studied with great caution. But they may be useful as corroborating evidence. Contemporary documents should also be subjected to test. Contemporaneity does not always make a document believable. Thus, selectivity becomes very helpful both in the cases of contemporary and non-contemporary documents.

Conclusion

It is essential to check and cross-check the data from as many sources as possible. It is important to arrange the matter into logical sequence and to reconstruct the situation. A proper reconstruction of the situation requires knowledge and understanding of a large degree. The reconstruction of the situation is the first step towards the synthesis of facts. A successful application of the historical method requires careful, tolerant, sympathetic but critical attitude on the part of the researcher. In the words of Pauline Young, "historical data drawn from a variety of sources, judiciously chosen, critically examined and discriminatingly used, may constitute a fund of knowledge indispensable in understanding and generalising on community phenomena, the social milieu and social institution."

COMPARATIVE EVOLUTIONARY OR GENETIC METHOD

This method attempts to support the thesis of organic development according to the fixed stage. Comparative method is applied,

generally, to the theory of biological evolution. In social anthropology, this method is frequently employed to show the evolutionary stages and forms of social institutions. Comparative anatomy becomes the basis of argument for organic evolution. This can be seen in the attempt to arrange plants and animals according to certain resemblances regarding anatomical structure. For instance, the tails of cows, monkey, buffaloes, dogs, etc., are arranged in such a series. It is the general conclusion that the "species have arisen in time in the order presented in the series."

We may examine the working of this method in social anthropology. For instance, the institution of marriage has passed through several stages, e.g., promiscuity in the very primitive stage, group marriage next, then maternal clan followed by paternal clan, and lastly, we have the individual monogamous arrangement of marriage which is considered to be the basic and most advanced stage of the institution of marriage. These stages or orders of the institution of marriage are discovered by studying the marriage patterns of some tribes. The prevalence of different stages of marriage in different tribes indicates a temporal sequence in such a fashion that stage first must have preceded stage second, which in turn is followed by stage third, and so on; and that a tribe in a certain stage at present must have passed through the earlier stage or stages.

However, temporal order or order in time, is not the same as logical order. A confusion between these two orders was created by the uncritical use of the comparative method by Morgan, Spencer, etc. Institutional forms belong to different historical series, each having a definite position in the tribal history where it is noticed. Therefore, unless we appreciate the evolutionary theory of stages beforehand, we cannot arrange the social institutions in a logical order, as required by the evolutionary theory. In other words, if we do not assume that the sequence of stages in each of the different tribes is identical, we do not have any evidence at all. But in assuming this, we commit the fallacy of arguing in a circle, because this assumption itself is tantamount to the theory of social evolution. Another mistake is committed when superficial resemblances are taken for granted as significant similarities. For instance we cannot be definite in saying that since all people have ideas, all people are similar. For, the forms of ideas may be very much different. Again, the act of killing human beings, for example, may be prevalent in different groups, but the motives may be so different that a direct comparison of group killings would not be of any significance. Formal ideas and actions, though alike broadly and generally, cannot often be compared because of the minute and fundamental cultural and psychological differences between them.

DESCRIPTIVE METHOD

The descriptive method is simple, and easily applicable to

various social problems, particularly in developing countries. It is a fact finding approach related mainly to the present, and abstracting generalisations through the cross-sectional study of the present situation.[7] This method is mainly concerned with the collection of data. But since mere collection of data does not constitute research, unless the data are properly interpreted to find the causal connections and relations, the descriptive method, to some extent, is also concerned with the interpretation of data.

Significance and Importance

The descriptive method is more commonly used in social sciences, socio-economic surveys, job and activity analysis.[8] But the method is also extensively used in physical and natural sciences, e.g. in measurement in physics, in dissection in zoology, in classification in biology, in the study of rocks in geology, etc. Sociological problems are generally descriptive. The objective of socio-economic surveys is to describe, analyse and interpret social and economic institutions, area or group with a view to drawing out generalisations which are either helpful to solve the problem directly or to guide other investigations. Job analysis takes note of the manpower available and the manpower required for different jobs in various professions.

However, all types of problems in social sciences cannot be subjected to the descriptive method. Mainly, the complex theoretical and philosophical problems are out of the purview of this method of approach. The descriptive method can be applied if the problem to be analysed fulfils certain criteria. Firstly, the problem must be capable of being described and not merely argued about. For instance, international monetary institutions—their objectives, structures, techniques, failures and achievements etc., can be studied descriptively. But the choice of a particular theory does not depend on description but on reasoning, although the theory itself is descriptive. Thus, the question whether one or the other growth model is acceptable, is dependent largely on reasoning and, therefore, is not amenable to the descriptive method. Keynes' *General Theory* and Hicks' *Value and Capital* do not follow the descriptive method, but Hawtrey's *A Century of Bank Rate* does. At the present state of our knowledge, the conditions and problems of developing economies, mostly, can be made amenable to descriptive method.

In order to apply the descriptive method, the data should be accurate, objective and, if possible, quantifiable. This will make

7. M.H. Gopal, *An Introduction to Research Procedure in Social Sciences*; p. 74.
8. E.B. Renter, "An Evaluation of the Subjective Methods of Sociological Research", *Journal of Educational Psychology*, 1935.

the data more satisfactory and reliable. But all situations and data do not fish out quantitative information. However, one must ensure that the descriptions are objective, adequate and accurate so that a detailed picture of the situation may be collected without any difficulty. Accuracy does not mean the discovery of every relation or aspect of the problem; it simply means the finding out of as much detail as possible under given situations and presenting the details in an unbiased manner. Some problems are by nature quantitative and some are not. For example, the study of the wages of labour can give quantitative information, but the study of the functions of rural institutions will not.

Since the descriptive method wants to relate causally the collected facts, it is necessary for it to make comparisons between one situation and the other, and between different aspects of the same situation. Thus, situational comparability is an essential element of this method. But in order to be amenable to comparison, the situations must be similar. This is where the judgement and imagination of the researcher regarding different situations have to play their part. In order to present the continuity of ideas and to demarcate the line of solution, the researcher should relate the facts to time and place before any comparison is made. The researcher, after collecting the facts, should provide interpretations. He must provide the scope and direction for checking his own methodology and facts, and should also suggest the direction in which further research is necessary and possible. Here the descriptive method should demand at least three important things (i) an accurate and adequate bibliography relating to the problem studied, (ii) an elaboration of the applied methodology for the collection and analysis of facts and (iii) a list of the unsolved but relevant problems encountered by the researcher.

Limitations

Mere description of a problem does not constitute research. Research entails discovery of facts, and it is essentially creative. Every problem has its past, present and future. The description of a problem is only one phase; it does not speak entirely of the problem. What is dangerous is an unprogressive conservative attitude which may also be reflected in the collection of facts. Another limitation arises out of the extreme tendency to over-use statistics. Partly, statistics is a descriptive tool; but it cannot always be helpful to find out causal relations in an accurate manner. Instead of being used as a servant, statistical techniques ares ometimes used as a master.

SCIENTIFIC METHOD*

Method or Approach?

The overall approach to research of any variety is what is

*For further details, see the Section on Scientific Method (Infra)

generally termed as the "scientific method". Scientific method comprises three steps—*observation*, *hypothesis* and *verification*. However; these steps are applied both in the cases of physical and social sciences. This method is called the genus, and the different individual methods are the species. Scientific method is less of a method, but more of a general philosophy of research. There are as many scientific methods as there are different varieties of problems. According to Prof. Northrop, scientific methods are relative to the stage of enquiry and the type of problem.[9] Different stages of enquiry may have different scientific methods, and the method which is scientific for one stage may not be so for another. In fact, there is no monism in scientific method.[10] As there are multiplicity in sciences, there are multiplicity in rational methods. Prof. Caldin holds that there are several types of rational methods. Prof. Hook draws a distinction between scientific technique and scientific method. The former is the instrument available for any research and the latter is the special method of any particular science.

Profs. Cohen and Nagel regard the scientific method as the most assured technique for controlling things and establishing stable belief. It is based on systematic doubt, and it aims at discovering the actual facts and the rational inter-connection of facts. It wants to establish general propositions through weighing the evidence. Mehlberg points out that the problems which are not accessible to scientific method are meaningless problems. However, it is not the facts themselves which make science but the method by which they are dealt with. However, since a distinction is useful between approach, method and techniqne, it is rational to regard scientific method not as a method in the sense as historical, descriptive and other methods. As Prof. Marganan observes, scientific method, being highly elastic, can be made applicable to all domains of human activity where the discovery of truth is the objective.[11] *Encyclopaedia Britannica* defines this method thus: "Scientific Method is a collective term denoting the various processes by the aid of which the sciences are built up. In a wide sense, any method of investigation by which scientific or other impartial and systematic knowledge is acquired is called a scientific method,"[12] However, the features of scientific approach are *mutatis mutandis* applicable to all methods. The pattern of scientific investigation, incorporating a number of methods, constitutes concentric circles in the research procedure.

The scientific approach has two constituent elements—procedural and personal. They are described as follows:

9. F.S.G. Northrop, *The Logic of the Sciences and Humanities*, *p. 19.*
10. Litt, "Method in Science" in *Science and Freedom*, 1955. p. 141.
11. *Science and Freedom*, p. 147.
12. 1941 *Encyclopaedia Britannica*, Vol. XX p. 127.

Procedural Components

Observation, hypothesis and verification are the three procedural components in a scientific approach. Observation is based on data currently available. Observation depends on knowledge, material and personal hunches. Observation helps to build up hypothesis. It also helps as a technique of collection of data, thereby helping verification. The second step is the formulation of one or more hypothesis. A hypothesis is a tentative conclusion. The main function of a hypothesis is to guide the collection and processing of materials, and direct investigation. The third step is the verification of hypothesis and arriving at a generalisation. Verification is helped by analytical tools. The tools of collection and analysis are available techniques used for checking and counter checking. Tools help in the careful definition of the concepts and in the collection of the comprehensive data. Even in social sciences, statistical or quantitative tool is coming into greater use.

Personal Components

The researchers need imagination, analytical ability, resourcefulness, skill, persistence and independence. The capacity to find the heart of the problem is a part of the enquiry. The knowledge of the field of investigation is a fact of the personal component. Researcher's ability and attitude are more important than the method of approach. He should have an objective, scientific and unbiased view. He should have sufficient personal qualifications and professional training, apart from practical experience. The personal qualifications must enable the researcher sufficiently to assess the adequacy, relevance and value of the data. Personal quality also relates to integrity, honesty, truthfulness and sincerity of purpose. At every step, the researcher requires reasoning. There is a greater need for balance or poise between mental, physical and moral qualities. Poise gives the ability to see things in their true perspective. Ambition, interest and perseverance are very much required to go on successfully with research. In other words, a worthy researcher should possess the objectivity of Socrates, the wisdom of Solomon, the courage of David, the strength of Samson, the patience of Job, the leadership of Moses, the strategy of Alexander, the tolerance of the carpenter of Nazareth, and above all an intimate knowledge of every branch of the natural, biological and social sciences.

SCIENTIFIC METHOD*

Meaning

A scientific method is the way in which one can test opinions,

*This Section is entirely based on Cohen and Nagel's book, *An Introduction to Logic and Scientific Method*, Allied Publishers, 1968.

impressions or guesses by examining the available evidence both for and against them. It is simply the pursuit of truth which is determined by logical considerations. Scientific method is the most assured technique for controlling a host of things and establishing stable belief.

Essentials of Scientific Method

Scientific method aims at discovering facts. But facts cannot be discovered without some reflective enquiry. Every fact is initially nothing but some proposition or problem. At every stage of enquiry hypothesis is necessary. Hypothesis is regarded as a suggestion of possible conditions between imagined fact and actual fact. The deductive elaboration of hypothesis is not the only function of scientific method. Scientific enquiry has to determine which of the possible explanations is in best conformity with the facts. Every enquiry depends first on the probable inference: further enquiry decreases or increases the probability.

Scientific enquiry is based on systematic doubt. When facts demand, science may abandon a theory. When new and more probable facts are found, the earlier facts containing at heory are given up. Verification of theories at a particular point of time is only approximate.

When a science proceeds in this way, it becomes progressive. Science aims at establishing a systematic interlinking of facts. The evidence for a proposition may be collected from its own verifying instances, or from the verifying instances of other relevant propositions. This systematic character of scientific theories is responsible for high probabilities of their propositions.

Scientific method is self-corrective in nature. It depends on the methods of developing and testing hypothesis. The method of enquiry itself may be tested and modified. Since scientific method is based on the most probable inference at a particular point of time, a scientific theory is more probable than any other alternative theory. The method of science depends on evidence which is collected from empirical material on the basis of principle. In the process of such dealings, the doubtful matters are detected and clarified.

Scientific theories are abstract in nature. A theory accepts only relevant matter, and rejects others which are either irrelevant or have a minor or insignificant influence on the theory.

Scientific explanation rests on certain laws which seek to explain events of particular types. Laws are the consequences of more comprehensive theories, and may themselves be checked. However, there may be different types of theories. For instance, physical theories depend upon hidden mechanism (models),

mathematical or abstractive theories make use of relations abstracted from the phenomena actually observable, and a synthesis or fusion type of theory works with both kinds of theories.

Nature of Scientific Method

The nature of scientific method depends upon the nature and objective of a particular science.

There are, broadly, two methods of science:

(i) Technical (Technological) and (ii) Logical.

(i) *Technical Method*: For proper observation and experiment, a science, for its investigation, develops certain technological relations or facts against which the observed facts are considered. Technical methods may imply the use of certain instruments. The more developed the technical method, the more exact a science becomes in handling data required for experiment. The use of technical methods makes a science progressive.

(ii) *Logical Method*: Since science is a systematised knowledge, the importance of the method of reasoning or logic can hardly be overestimated. Logic is the science of reasoning. It formulates conditions through which the validity of reasoning may be tested. Reasoning consists of arriving at a conclusion from certain premise or premises. The process of deducing a conclusion from a premise is called inference, which is nothing but derived knowledge. All knowledge consists of assertions or propositions. Inferences is a proposition which is derived from some other proposition. A valid inference is one in which the conclusion follows reasonably from the premise. For ascertaining a valid conclusion, a science should depend on logical method. Scientific method is, therefore, the persistent application of logic as the common feature of all systematic and reasoned knowledge.[13]

Formal Logic

Logic is an instrument of reasoning; and its character is formal. Logical validity cannot ensure the correctness of the subject-matter of science. Logic is more like Grammar which deals with the correctness of the form or the structure of language, but not with the correctness of the matter of the language. Similarly, logic studies the form or structure of reasoning and formulates the conditions for the validity of reasoning, but it does not and cannot study the material correctness or incorrectness of a premise or a conclusion. Logic is formal because it studies the form or structure of reasoning.

13. Cohen and Nagel, *An Introduction to Logic and Scientific Method*; Allied Publishers, 1968, p. 192.

Pattern of Scientific Method:

The pattern of scientific method consists of :

(1) Hypothesis

(2) Testing of Hypothesis

(3) Observation and Experiment

(4) Formulation of Laws

(5) Construction of Theories

(6) Testing of Theories

Logic and Scientific Method

Logic involves reasoned knowledge; and all sciences are applied logic. The universal feature of science is its general method which consists in the persistent search for truth. But the search for truth depends on evidence, the determination of which we call logic.

We believe in a thing because of many factors: tenacity, authority; superstition, intuition etc. But seeing or mere believing is not believing in the true sense of the term. All the above factors are not free from human caprice and willingness. Scientific method is an enquiry to ascertain the validity of beliefs, hypotheses and propositions through factual evidence. Such a method having objective connections, should, then, be found reasonable, because it can be tested. Scientific method is flexible and encourages doubts, and what is left after doubt is always supported by the best available evidence. When new doubts or evidence arise, scientific method incorporates them as an integral part of the existing body of knowledge. The method makes science progressive, because it is never too certain about its results.[14] Formal logic is helpful in scientific method in that it devises ways of formulating propositions correctly and explicitly so that their possible alternatives become clear.[15] When alternative hypotheses are framed, logic develops its consequences which, when compared to observable phenomena, can be the means of testing the validity or otherwise of a hypothesis.

Value and Use of Scientific Method

Possession of knowledge is a universal human urge. But the desire to know is not often strong enough to sustain a critical type of enquiry. Institutions of knowledge cannot give any proof that contrary institutions are wrong. Scientific method is concerned with verification of the acquired knowledge. It finds out some

14. *ibid*, p. 195.
15. *ibid*, p. 196.

order in which things are related together. The conclusion which is arrived at by the scientific method has an objective validity. The objective nature of the scientific method is its greatest quality. Scientific method is the only way to increase the general body of tested knowledge and to eliminate arbitrary and ambiguous opinion. Scientific method springs from the desire to acquire truth, and when this desire is very strong in a community, the progress of scientific method becomes rapid and smooth. The method, however, may not always lead to the final destination of truth, but "enables large numbers to walk with surer step". It certainly minimises the dangers associated with novelty, adventure and uncertainty. It lays down policies and standard of moral judgement with a broader outlook than those of organic response or wild stimulus. It strengthens the love for truth and courage for overcoming illusions. It settles differences in a rational way, which is appealing to all. It is beyond a narrow outlook and subjective elements which are sometimes petty. It unites men through its noble and rational procedure. "Because it requires detachment, disinterestedness, it is the finest flower and test of a liberal civilisation".

Difficulties in the Use of Scientific Method in Social Sciences

Some people argue that scientific method is more applicable to physical or exact sciences and it cannot be applied to social sciences which deal with human behaviour. Those holding this opinion point out the following difficulties in the use of scientific method :

1. Human behaviour is complicated, subtle and varied. Therefore, it is very difficult to categorise human behaviour.

2. When human behaviour is studied and analysed by other human beings, the personal characteristics of such human beings come into the picture and distort the analytical facts.

3. Different aspects of human behaviour are psychological in nature, and as such, do not admit of measurement.

4. Human behaviour is not uniform and predictable. It is more often than not, uncertain. All people do not behave in the same way in similar circumstances. Similarly, one individual may behave differently under similar circumstances.

5. The choice or decision involving humans, which is essential for observing human behaviour for the use of the method of experiment, becomes difficult. Thus reliable scientific data cannot always be collected.

Scope

But today it is held that even in social sciences, which deal with human behaviour, the use of scientific method cannot altogether be ruled out. The difficulties are overcome in the following ways :

(i) Human society is progressing through predictions of human behaviour ; and in most of the cases, predictions come to be true. The variations, if any, become a matter of degree. Under particular circumstances, most human beings behave in a particular way—the individual variation, however, is there, but class variations generally do not occur. Thus, there is nothing to prevent broad generalisation. A science progresses by making abstractions. The discovery of common features for general knowledge is an essential element of the scientific method. The finding of class-behaviour means the discovery of uniformity which represents the order of things. And predictions can be based on order or uniformity.

(ii) The personal prejudices of an observer of human behaviour in social sciences can be minimised with the help of some standard techniques developed for that purpose. In economics, the use of *numeraire* helps to serve such a purpose. The marginal utility of a thing to a consumer (which is essentially psychological) is presumed to be equivalent to the price which a consumer is prepared to pay for the commodity. Money serves as a measuring rod. Presently, standard techniques are being developed for the observation of, and experiment upon human behaviour, and for the collection and interpretation of data. The objective of such techniques is to eliminate the subjective bias in the analytical framework of scientific theories. In economics, mathematical tools are being used to successfully study human behaviour. Psychology, which is concerned with the study of mind, has developed many techniques for measuring I.Q., personality etc. Similarly, Criminology has developed, among other things, the lie detector which seeks to catch a particular aspect of human psychology.

(iii) In social sciences difficulties in observation and experiment may be reduced to a considerable extent by making the enquiry confined to a particular class whose behaviour is taken up for study. If the analysis is carried on for the same situations, circumstances, environment, institutions etc., it can be broadly realistic and successful.

(iv) The existence of complex phenomena does not eliminate the possibility of using the scientific method altogether. Physical sciences (for example, nuclear physics) are sometimes conformed with complex situations, but scientific method is successfully used there.[16]

It is clear, therefore, that scientific method has ample scope in social sciences. It can be used, by and large successfully, in the study of social phenomena and in predicting human behaviour. But one must make a difference between the laws of physical sciences and the laws of social sciences. Laws of physical sciences

16. Goode and Hatt : *Methods in Social Sciences Research*, p. 3.

are uniform and exact. A single negative instance would necessitate the revision of the physical law. But in social sciences, laws are statistical averages and express only tendencies ; and as such, they are not exact or uniform.

Limitations of Scientific Method

Scientific method has the following limitations :

1. Scientific method involves abstraction.

2. Scientific explanation is never complete. At every stage, there are some basic principles which remain unexplained in social sciences.

3. The conclusions arrived at by scientific method are not final. They are only relative to observed phenomena, facts discovered and reasoning developed.

4. Sciences have limited scope. Each science is concerned with a particular area and is based on certain assumptions.

5. Superstitions, cherished beliefs etc., are hostile to the growth of scientific method. Institutionists, authoritarians, fictionalists and mystics often undermine the respect for scientific method.

6. Formal procedures are fruitless. Definitions and formal distinctions are not often used properly; and statistical informations may be irrelevant and inconclusive.

7. Scientific judgement is difficult, and sometimes impossible, when situations demand immediate action.

8. The growth of scientific method in a society where there is no desire for truth, or freedom for the expression of intellectual doubt, is surely hampered. "Fear of offending established dogmas has been an obstacle to the growth of astronomy and geology and other physical sciences."

9. The necessary time for reflection, and material for experiments are often lacking for the proper development of scientific method.

10. Scientific researches in social field are often in the hands of those who cannot always oppose the established opinion or taboos.

11. No scientific method can guarantee certainty of achieving the goal and can prevent human life from being an adventure.

The Abuses of Scientific Method

Fallacies of Reduction : Science analyses objects into their constituent elements. But sometimes a misconception is formed that

science identifies objects with their elements. This gives rise to two wrong notions : (i) that science denies the reality of connecting links or relations, and (ii) that science is a falsification of reality. The former mistakes arise when, e.g., we regard scientific books as nothing but words, and society as nothing but individuals. Again, science is not a falsification of reality. It explains reality as a combined effect of certain elements in right proportions, e.g., water consisting of hydrogen and oxygen.

The Fallacy of Simplism or Pseudo-Simplicity : Science gives the simplest account of a systematic body of knowledge. But this does not mean that out of two hypothesis, the simpler is true. Truth cannot be identified with simplicity.

Some people, again mistakenly argue that something, say production, is more fundamental to another, say, consumption. This is erroneous, because there may be two factors, which continually modify each other. Such an error is known as the *fallacy of absolute priority.*

The Fallacy of Exclusive Linearity assumes that a number of factors are so related that a linear series may be formed. This can be noticed in the attempts made by Kent in arranging human faculties.

The Fallacy of Initial Prediction presupposes the readily known feature of a thing to be its ultimate nature.

The Fallacy of False Opposition or Disjunction is a special form of simplism. It denies disharmony or conflict if there is some harmony of interests; and it denies harmony of interests if there is conflict and disharmony. There is the erroneous logical assumption that all alternatives are mutually exclusive. There may be conflict between labour and capital in the matter of sharing of product, but there is similarity of interests in the matter of protective tariff against a foreign industry. The *fallacy of false disjunction* involves the argument that things cannot be constant if they change, and *vice versa*. However, it is obvious that there is no change without some constancy and no constancy except relative to change.

It is wrong to assume that abstract is unreal. Abstract sciences do not unfold the whole of reality ; but they are not unreal.

The Fallacy of Exclusive Particularity assumes that a "term which stands in one relation within one context cannot stand in any other relation within the same or other contexts". It is assumed that if a person is honest on one occasion, the same person cannot be dishonest on other occasions. This is however, a false idea.

A dangerous fallacy is committed when it is thought that because a certain theory can fully explain a problem, every other theory on that problem is false.

Another form of *fallacy of simplism or false economy* is the confusion between necessary condition and sufficient condition. Both are required to prove a phenomenon adequately. Change in demand may be a necessary condition for a change in price, but never a sufficient condition, which may be provided by cost of production, and other factors.

The Genetic Fallacy : Temporal orders of history cannot be deduced from logical order. The evolution of historical events do not conform to particular logic. It is an error to suppose that an actual history of any science can take the place of logical analysis of its structure. Science is concerned with human knowledge; but the subject matter of a science is something which existed even before human knowledge. The temporal order is not, however, the same as the logical order.

3

HYPOTHESIS

Meaning

A hypothesis is a tentative generalisation, the validity of which has got to be tested. A hypothesis, at its initial stage, may be an imagined idea or mere guess. A hypothesis is based on accumulated previous knowledge. A hypothesis is made in order to find out the correct explanation of a phenomenon through investigation. On the basis of the hypothesis, facts are observed and collected. When, by verification, the hypothesis is found to be true, a theory is obtained.

Functions of Hypothesis

1. The most important function of a hypothesis is to adequately explain all the facts connected with the hypothesis.

2. It enables us to direct enquiry along the right lines. It suggests experiments and observation. It helps to collect necessary evidence in order to discover the order of nature.

3. Hypothesis determines the method of verification as well as the procedure for enquiry. Hypothesis limits the scope of enquiry to a manageable area, because, instead of random collection of data, it enables us to search only for relevant facts. Therefore, it leads to economy of time and money.

4. It leads to the discovery of laws. It explains facts and laws, and thus seeks to verify knowledge.

5. Hypothesis leads to conclusion which is sometimes very significant for the advancement of knowledge. The significance of an object or event can be determined by a hypothesis.

Conditions for a Valid (Good) Hypothesis

1. The most important condition for a valid hypothesis is that it should be empirically verifiable. A hypothesis should be compared with the facts of experience directly or indirectly. A

hypothesis has ultimately got to be confirmed or refuted; otherwise it will remain a mere supposition.

2. A hypothesis must provide answer to the problem which initiated enquiry. A false hypothesis is not always useless. It may encourage further investigation and attempt to find out relations among facts and thereby, may increase the evidence for other theories.

3. In case we have more than one hypotheses, we should prefer the one which has a strong power of predictability and which can explain the consequences.

4. If there are two hypotheses on the same problem and if they can be equally confirmed by evidence, the simpler hypothesis is generally chosen. A hypothesis is simpler than other, if the first is more general in nature and has fewer assumptions and a smaller number of independent elements. But simplicity should not be confused with familiarity. A new and unfamiliar hypothesis should never be adopted merely for its simplicity.

5. A valid hypothesis generally does not go against the traditionally established knowledge. But a hypothesis may not always be invalid, if it goes against well-established knowledge; for the traditional knowledge may itself be wrong.

6. A hypothesis must be clear, definite and certain. It should not be vague or ambiguous.

7. A valid hypothesis suggests an explanation which appears reasonably true in the present state of knowledge. A fanciful idea or an absurd imagination does not make a valid hypothesis.

Formulation of Hypothesis

The formulation of hypothesis presupposes some problems for which enquiry is necessary. If there is no problem, no enquiry is needed, and there would be no necessity for a hypothesis. A satisfactory solution of any problem requires that the irrelevant facts be eliminated from the relevant facts. The formulation of hypothesis gives the direction in which the facts are to be arranged. We cannot go forward unless we begin with a suggested explanation of the phenomenon. This suggested explanation is called hypothesis.

However, there is no definite set of rules which can be laid down for the formulation of hypothesis. Partly, it is a matter of hitting upon an idea on some problem. The people with discerning minds are more capable of doing it. According to Stebbing, "every hypothesis springs from the union of knowledge and sagacity."[1] Previous knowledge of the field of enquiry plays a significant part for the formulation of hypothesis. In directing an enquiry, a

1. L.S. Stebbing, *A Modern Introduction to Logic*, p. 304.

hypothesis must take some facts as significant. A relevant hypothesis expresses determinate modes of connections between a set of facts, including the fact investigated. However, "in the absence of knowledge concerning a subject-matter, we can make no well founded judgements of relevance."

The deductive development of a hypothesis must follow from its formulation. Therefore, scientific procedure in this regard pays an important role. However, one must be fully acquainted with the facts and theories already existing in respect of the phenomenon with which one is engaged. The possession of such knowledge depends to a great extent on one's experience and insight.

Analogy and Formulation of Hypothesis

Analogy implies similarity. If previously established knowledge can be used in hypothesis, analogy must be noted and exploited. Previous knowledge contributes towards the formulation of hypothesis through analogies. Resemblances or analogies should be noted between the facts we are attempting to explain, and some other facts, the explanation of which is already known. But all analogies are, however, not significant.

However, we do not always start with explicit analogies. We may start with vague resemblances; and then by careful enquiry, we may develop an explicit analogy in structure or function. At the time of formulation of a hypothesis, analogy is not always considered. Nevertheless, a hypothesis is generally satisfactory when it has some structural analogies to other well-established theories. In the formulation of a hypothesis, it is difficult to meet this condition. The analogy of a hypothesis to others is helpful for the systematic simplicity of our knowledge. It is really an achievement if we formulate hypotheses analogous to others. Analogy makes the interpretation of a hypothesis easy.

Types of Hypotheses[2]

There are mainly two types of hypotheses : (i) Crude and (ii) Refined. A crude hypothesis is at the low level of abstraction. It indicates the kind of data to be collected, and it does not lead to higher theoretical research. The refined hypothesis is more significant in research. Refined hypotheses are of three types. The simple level hypothesis indicates merely the uniformity in social behaviour. It does not involve much verification. A complex ideal hypothesis is at higher level of abstraction. This hypothesis examines the logically derived relations between the empirical uniformities. This type of hypothesis is useful in developing tools of analysis. It provides constructs for further hypothesising.

2. See, Goode and Hatt, op. cit, pp. 59ff. And M.H. Gopal, *An Introduction to Research Procedure in Social Sciences*, pp. 119-20.

Another type of refined hypothesis is very complex. It is concerned with the interrelations of multiple variables. For example, in order to study family planning and human fertility in backward countries, a number of complex factors such as wealth, religion, culture, tradition, health, etc., have to be considered.

Forms of Hypothesis

(i) *Hypothesis concerning Law* : This explains how an agent works to produce a particular effect or event.

(ii) *Hypothesis concerning an Agent* : The law of operation of an agent is known, but the agent which is working to produce an effect may not be known. This hypothesis is framed to find out agent.

(iii) *Hypothesis concerning Collocation* : Collocation means an arrangement of circumstances. When a hypothesis is made relating to the circumstances necessary to produce a phenomenon, it is known as a hypothesis regarding collocation.

(iv) *Descriptive Hypothesis* : It describes the cause and effect relationship of a phenomenon.

(v) *Explanatory Hypothesis* : It explains the happening of a phenomenon. It reconstructs the situation by extrapolation and arrangement of facts.

Null Hypothesis

It is a hypothesis being tested (H_0). It is null because it may be nullified if the evidence of random sampling from the population specified by the hypothesis is unfavourable to the hypothesis. It is an important concept that is widely used in the sampling theory. It forms the basis of many tests of significance. The rejection of a null hypothesis implies that the difference could not have arisen due to chance and the acceptance of null hypothesis indicates that the difference is due to chance. This hypothesis determines the type I error.

Null Hypothesis : Null means zero. When hypothesis is stated negatively, it is called a null hypothesis. The objective of this hypothesis is to avoid the personal bias of the investigator in the matter of collection of data. A null hypothesis is used to collect additional support for the known hypothesis.

Verification and Proof Hypothesis

Verification of hypothesis means the testing of the truth of the hypothesis in the light of facts. For verification, there must be the agreement between the inference of the hypothesis and the observed facts. The greater the agreement, the stronger is the hypothesis. Direct verification means the direct appeal to the

fact of experience through simple observation or experiment. Where a hypothesis cannot be directly verified, it should be verified indirectly. In indirect verification, the consequences deduced from the hypothesis are compared to facts. If there is an agreement between consequences and facts, a hypothesis is verified. If facts agree with the hypothesis and, there is no contradictory fact, the hypothesis is verified.

In order to prove a hypothesis, it is essential first to verify it. However, verification is not conclusive proof. Thus, something more is necessary. A hypothesis must adequately explain all facts for which it has been made, and it must be the only hypothesis to do so. It must also explain all related facts, and it should have the power of prediction.

Sometimes two or more hypotheses may explain facts. Then, in order to know which one of them provides the real explanation, we take a crucial instance. This can be found out by observation or by experiment. A crucial instance is an instance which can only be explained by one of the contending hypotheses, and not by the other. This instance not only confirms a hypothesis, but it also negates the other. Suppose that a hypothesis is that X has committed a theft, another hypothesis is that Y has committed the theft. In course of investigation, it is found that X was present at a very distant place at the time when the theft was committed. Then, this is a crucial instance. However, disproving and eliminating its rival hypothesis does not imply that the original hypothesis is proved. Elimination of its rival hypothesis or verification of a hypothesis only indicates that the original hypothesis is more probable. However, a crucial instance obtained by experiment has a greater value for the proof of the hypothesis as compared to the crucial instance obtained by simple observation.

Testing of Hypothesis

It is a rule for deciding whether an assumption (hypothesis) about the distribution of a random variable should be accepted or rejected, using a sample from the distribution. The assumption is called the null hypothesis, H_0, and it is tested against some alternative hypothesis, H_1. For example when a coin is tossed H_0 can be P (head)$=1/2$ and H_1 that P (heads) $>1/2$. A statistic is computed from the sample data. If it falls in the critical region, where the value of the statistic is significantly different from that expected under H_0, H_0 is rejected in favour of H_1. Otherwise H_1 is accepted. A type I error occurs if H_0 is rejected when it should be accepted. A type II error occurs if it is accepted when it should be rejected. The significant level of the test, a, is the maximum probability with which a type I error can be risked. For example, a$=1$ per cent means H_0 is wrongly rejected in one case out of 100.

Hypothesis, Theory, Law and Fact

Hypothesis, Theory, Law and Fact are inter-connected. At the first stage of enquiry, a hypothesis is made, which is only a tentative supposition or guess. When a hypothesis is verified and found to be true, it becomes a theory. This theory, when it works satisfactorily and is proved, is generally accepted. It then becomes an instrument of further explanation and prediction. At this stage, the theory becomes a law. However, these stages are not very distinct, marked or definite. A fact is anything which is there or which can be conceived of. It is a concrete event of experience. Facts may be external or internal (of mind). External are perceived by our sense organs and internal facts are known by our minds. Well-established facts are sometimes regarded as laws. A science begins with facts and ends in facts. As concrete experiences, facts suggest hypothesis. The hypothesis ripens into a theory—a theory into a law and the law becomes so familiar that it becomes a fact.

Uses of Hypothesis

1. Hypothesis forms the starting point of investigation.
2. Hypothesis makes observation and experiment possible.
3. Hypothesis is an aid to explanation.
4. Hypothesis makes deduction possible.

Hypothesis and Science

A hypothesis is indispensable for any scientific investigation. The hypothesis always guides and gives direction to the scientific investigation. Without a hypothesis, a scientist can not know as to what to observe and how to observe. Without a hypothesis, an investigation becomes unfocused. The scientist in that case has to beat about the bush. According to Northrop, "The function of a hypothesis is to direct our search for order among facts, the suggestions formulated in any hypothesis may be solution to the problem. Whether they are, is the task of the enquiry."

In the deductive development of hypothesis, new consequences are provided. Many experiments need to be conducted for confirming the hypothesis. In this process, many new facts are developed and the knowledge of the scientist gets expanded. Every hypothesis aims at explaining the facts. Even if a hypothesis is rejected, it can be of great service in pointing out the way to true hypothesis. A false hypothesis also shows the direction to the required enquiry. Thus, a scientific investigation cannot dispense with a hypothesis. As Cohen and Nagel observe, "Hypotheses are required at every stage of an inquiry. It must not be forgotton that what are called general principles or laws can be applied to a present, still unterminated inquiry only with some risk. For they may not in fact be applicable. The general laws of any science function as hypothesis, which guide the inquiry in all its phases."

4

DEDUCTION AND INDUCTION

Deduction

Deduction is the process of drawing generalisation, through a process of reasoning on the basis of certain assumptions which are either self-evident or based on observation. In deduction, we deduce generalisations from universal to particular. Deduction can give conclusive evidence. Depending upon the premises, every deductive reasoning is either valid or invalid. The main task of deductive logic is to clarify the nature of relation between premises and conclusions in valid arguments. It is concerned with the working out of logical implications between propositions. Let us consider an example:

> All men are mortal.
> John is a man.
> ∴ John is mortal.

Here, the conclusion follows from the two premises logically. Therefore, it is valid. Whether a proposition follows from another proposition or not, depends upon the form or structure of the two propositions. Let us take another example:

> Some men are honest.
> John is a man.
> ∴ John is honest.

Here the reasoning is not valid, because the conclusion does not automatically follow from the premises. The structure or the form of reasoning here is not valid.

Logical implication does not depend upon the material truth of the premises. The premises may be materially false, but yet the reasoning may be correct. Deductive reasoning does not wait to examine the material truth of the propositions. Let us take an example:

If Bhutan was a democracy and no democracy had any kings, it follows that Bhutan had no king. The falsity of the proposition, "Bhutan was a democracy" does not prevent us from drawing certain logical implications.

Logical implication, involving deductive reasoning, is formal in the sense that it holds between all propositions, provided they stand each other in certain relations. A form implies something where different objects agree, so that the objects may be varied, but the form remains the same. Let us take another example:

John is an adult.
All adults are eligible to vote.
∴ John is eligible to vote.

Here, all the peculiarities of John are not brought in the argument. The fact that he is adult is sufficient for the argument. And, any name can be used instead of John, but the argument will still be valid. Deductive reasoning can be helpful in studying compatibility or incompatibility of different propositions.

Induction

Induction is a process of reasoning whereby we arrive at universal generalisations from particular facts. Induction gives rise to empirical generalisations, and is opposite to deduction. Induction involves a passage from observed to unobserved. Induction involves two processes—observation and generalisation. If, in a number of cases, it is observed that educated girls have got expensive habits, one may conclude that all educated girls have got expensive habits. This is the simplest kind of induction, and is called *induction by enumeration*. But scientific induction is based on known causal connection. Induction by enumeration gives us only probable conclusion, but scientific induction gives us certain conclusions.

A *perfect induction* is the process of establishing a universal proposition by an exhaustive enumeration of all the instances of the type covered by the universal proposition. Perfect induction is not opposite to deduction; but on the other hand, it is an example of deduction. The conclusion in perfect induction is arrived at by strict syllogistic reasoning. But since in perfect induction there is really no generalisation and there is no passage from observed to unobserved, it is not sometimes regarded as induction in the true sense of the term.

Intuitive induction is the process of arriving at a conclusion from intuition and from reasoning. It may be intuitively known that a particular patch of red is darker than a particular patch of pink. Here, the conclusion is direct and is based on perception which may be beyond any justification. In intuitive induction, no process of inference is involved. Therefore, there can be no logic of

intuitive induction. Intuitive induction is not also antithetical to deduction.

However, induction may be regarded as a method by means of which the material truth of the premises is established.

Induction (Generalisation) in Mathematics

Since mathematics is a deductive science, apparently, there cannot be anything like mathematical induction. But in fact, there is a method of mathematical induction which is purely a demonstrative method. The principles of mathematical induction may be discussed below:[1]

If a property belongs to the number 1, and if and when it belongs to n, it can be shown to belong to n+1. Then, it belongs to all the integers. This theorem can be demonstrated. For all integral values of n, $1+3+5+7+\ldots\ldots\ldots(2n-1)=n^2$

This is true when $n = 1$. But if it holds for the integer n, then it also holds for $(n+1)$

$1+3+5+9\ldots\ldots\ldots\ldots(2n-1)=n^2\ldots\ldots\ldots$(i)

$1+3+5+9\ldots\ldots(2n-1) + (2n+1) = n^2+(2n+1) = (n+1)^2\ldots\ldots$(ii)

(i) and (ii) have the same forms. Therefore, if the theorem is true for the integer n, it is also true for $(n+1)$. Now it is true for $n+1$. It is true, therefore, for $n=(1+1)$ or 2, and so on. Here, the proof is formal and deductive. It has no appeal, as Cohen and Nagel assert, to experiment. However, mathematical induction is a part of the very meaning of inductive (finite) numbers.

Generalisation brings about changes in the meaning of words. In mathematics, the same thing has happened in the case of modern generalisation of numbers. Number, traditionally, was confined to integers. The abstract nature of integers can be expressed by means of a set of propositions indicating the nature of operations and relations between the operations. If we do not enlarge our conception of number, the inverse operation of division cannot be performed. For instance, there is no integer x such that $x \times 5 = 7$. Consequently, fractions, had to be introduced. They are also called numbers. Thus, the area of number was increased in the interest of continuity and generality. Fractions is evident in the law of the series. However, according to Mill, this is no proper induction.

Distinction between Deduction and Induction

1. In deduction, we deduce generalisation from universal to particular, but in induction we arrive at universal generalisations from particular facts. Therefore, sometimes deduction is thought to be opposite to induction.

1. Cohen and Nagel, op. cit., p. 148.

2. The propositions from which deductions are made are assumed. But in induction this is not the case. Induction is concerned with discovering facts and relations between them. Observed facts provide the basis of induction, but they are not relevant for deduction.

3. Deduction is not concerned with the material truth of the premises; but induction is concerned with the establishment of the material truth of universal propositions.

4. In deduction, the conclusion only seeks to unfold what is in the premises. It does not go beyond premises. The conclusion in deduction, in other words, is never more general than the premises. But in induction, the conclusion goes beyond the premises or, what is in the data. Therefore, in induction, the conclusion is more general than the premises.

5. Deductive method gives us conclusions which are certain; but the conclusions of the inductive method are only probable and not always certain. This is so because the conclusion in deductive reasoning follows from the premises logically, or it is implied in the premises; but in inductive method, conclusion is not implied in the premises. Thus, the conclusion is certain, if we say that since all men are mortal, and Ram is a man, Ram is mortal. But the conclusion is only probable or uncertain, if we say that since some educated girls have expensive habits, all educated girls have expensive habits.

Merits of Deduction

1. It is a simple and easy method which is not time-consuming and expensive.

2. This method leads to accuracy and precision in generalisation because it makes use of logic, and mathematical tools of analysis. If the premises are true, we can easily get a true conclusion.

3. In a social science, like economics, where there is limited scope for experimentation, this method becomes the only available method for the development of the subject.

Demerits of Deduction

1. It is harmful, when universal validity is claimed for the generalisation arrived at by deduction, particularly, when the premises are incorrect or partially correct. If policy presrciptions are based on deduction, the consequences may be dangerous. The deductive "arm-chair" analysis should be taken with caution and care.

2. If the assumptions upon which deductive reasoning is based are untrue or partially true, the inferences drawn become automatically beyond truth, therefore having no operation validity.

3. Deductive method is abstract. If a large dose of abstraction is used in theorising the result is the creation of "intellectual toys" and useless "implicit theorising".

Merits of Induction

1. Inductive generalisations are based on observed facts and realistic foundation, and as such, they are precise and accurate.

2. Inductive method is scientific in character. Some of the important theorems of physical and social sciences have been developed through this method.

3. Inductive method underlines the relativity of laws or generalisations. It points out that a particular generalisation is valid under particular circumstances.

4. Induction supplies the universal premise and is helpful in finding out material truth.

Demerits of Induction

1. It is a time-consuming, expensive and a complicated method.
2. It often leads to hurried and wrong generalisation.

3. The collection of data for induction is a complex job. An investigator using this method requires high degree of competence and training, besides sophisticated tools of analysis.

4. Induction is not fruitful without deduction. Without deduction, induction becomes destructive and, produces only a mass of unrelated and unconnected facts.

Deductive-Inductive Method (Logical Positivism)

It is wrong to think that deduction and induction are opposite to each other. We have already seen that pure and intuitive inductions are not at all antithetical to deduction. In general, not all the premises required logically in induction, are known to be true. The specific problem of induction is to determine as to what extent the samples are fair. The proper contrast is not between deductive and inductive inferences, but between inferences which are necessary and inferences which are probable, because the evidence for universal propositions can never be more than probable.[2]

In sciences, the two methods are often used side by side. The combination of the two methods is known as deductive-inductive method, or logical positivism. It is now increasingly recognised that analytical (deductive) studies must be corroborated by empirical (inductive) studies. For analytical work, empirical study is regarded important for many reasons. The empirical generalisations can

2. *ibid.*, p. 279.

become the basis, and provide us the rationale for analytical works. Similarly, analytical studies are considered to be important for empirical research. Empiricism becomes meaningless unless it is guided by some principle, theory or analysis. Deductive-inductive method can be used in the indirect verification of hypothesis. When hypothesis cannot be compared directly with facts, then conclusions are deduced from the hypothesis, which are compared with the observed facts. When science discovers a law on the basis of observed facts by inductive generalisation, it can be demonstrated that the facts are deducible from the law. In deduction, certain propositions are deducible from the axioms (unproved assumptions); similarly, a scientific system is a form of deductive system in so far as the various laws are deduced from certain basic assumptions.

Pure deduction and pure induction are not meaningfully possible. A scientific method, which is perfect, has to be a marriage between the two. Deduction and induction are complementary rather than competitive. Both of them are needed for scientific thought as the right and left foot are needed for working.[3]

Hypothetico-Deductive Method

This method is not a purely inductive method. It is a combination of both deductive and inductive methods. This method is used extensively in scientific investigation. Here are the following four main stages of this method:

1. Feeling the problem.
2. Formulation of hypothesis.
3. Deductive development of hypothesis.
4. Verification of hypothesis.

First of all, a scientist must find out a problem on which investigation can be done. Such a problem is collected from our day-to-day experience.

Then, the scientist tries to give a tentative explanation of the phenomenon.

At the initial stage, some experience is necessary to pick up the significant aspects of the observed facts. Without the previous knowledge, it is very difficult to make a successful investigation. The hypothesis which is formulated must be capable of verification and proof. The formulated hypothesis must be able to fully explain the phenomenon.

The next step is the deductive development of hypothesis. In this process, the scientist makes use of deductive reasoning. He

3. Marshall, *Principles*, p. 29.

constructs the model based on deductive argument by supposing that the hypothesis is true. He constructs syllogism with the help which he gets from the conclusion. Such a conclusion is derived from the premises. In this way, a scientist can deduce the implications from the hypothesis.

The next stage is the stage of verification of hypothesis. In this stage, it is found out whether the conclusion drawn from deductive reasoning is true or not. Verification consists in finding whether the hypothesis agrees with the facts or not. If the hypothesis stands the test of verification, it is accepted as a correct hypothesis. This hypothesis is then called a theory. However, if the hypothesis is proved to be false, it is rejected. A hypothesis is the mid-way between facts and theory.

5

OBSERVATION AND EXPERIMENT

Observation and experiment jointly become the basis or the material grounds of induction. The material truth of an inductive reasoning can be established by the processes of observation and experiment.

Meaning of Observation

Observation means seeing things with a purpose. It consists in collecting the facts which are in the direct knowledge of the investigators. Observation is perception with a purpose. That is, observation is regulated perception. In observation, only the relevant things are taken into account. Therefore, it is essentially selective. Observation is the process of acquiring knowledge through the use of the sense organs. The observation of mental states, e.g., love, hatred etc., is called introspection. Observation, however, is not the same as unconscious inference. Observation is the knowledge directly gained through the sense organs. But inference is the process of passing from a known proposition to an unknown or implied proposition. Thus, inference is indirect knowledge. Sometimes, wrongly, hasty inference is confused with observation. This gives rise to a fallacy of mal-observation. Interpretation which is essential for observation, is not direct knowledge but is derived and inferred. Sometimes perception also is based on interpretation derived from indirect knowledge or experience. Thus, observation involves an element of inference.

Components of Observation[1]

Observation has three components, e.g., sensation, attention and perception. Sensation is derived from the sense organs. The accuracy of observation depends, to a great extent, on the power of the sensory organs, like eyes, ears, nose etc. Attention is related

1. M.H. Gopal, *An Introduction to Research Procedure in Social Science*, p. 175.

to the ability to concentrate on the object matter of study. Perception enables the mind to recognise the facts by identifying sensations and drawing upon experience and introspection. The accuracy of observation depends on knowledge and experience. However, initial knowledge sometimes may prejudice the observation. But it can be reduced by proper training and observer's cultivation of the habit of unbiasedness.

Types of Observation[2]

There are mainly two types of observation, e.g., controlled and uncontrolled. In controlled observation, no mechanical aid is used, and the data is collected without standardising method. The investigator thinks that he knows more than what he actually observes. Thus, dependable facts may not be collected through this type of observation. In order to avoid the ill-effects of this type of observation, controlled observation is introduced, which takes the help of mechanical instruments. It also uses the standardised method and tries to get representative samples.

Observation may be participant and non-participant. In the former type, the observer mixes himself and fully participates in the study by keeping himself inside the situation he is studying. The best way to know human beings is to study them by being one of them. Since participation minimises objectivity, it requires care, control and experience on the part of the observer to make a mental study of the situation.

Accuracy and Reliability of Observation

For accurate observation certain steps may be taken:

1. Formulation of the problem precisely and clearly.
2. Study of each item separately at a time.
3. Relation of observed fact with the problem at hand.
4. Study of the relevant facts—selectivity and objectivity.
5. "How, when, who, what, why and where" should be in the mind of the observer to answer while making observation.

The reliability of observation depends on three factors: (i) techniques and tools used, (ii) observed situation, and (iii) the quality of the observer.

The tools and techniques used in observation should be reliable and scientific. The units of observation should be homogeneous. The skill and measurement should be properly developed. There should be proper cross-checking. The selection of sample should be careful. The sample to be observed has to be representative. While observing situations, objectivity has to be maintained

2. *ibid*, p. 176.

throughout. The observer should have relevant experience, knowledge, imagination, maturity, alertness, unbiasedness and mental and physical fitness. The observed result should be written immediately after observation, and all observable behaviour should be categorised, so as to help proper understanding and analysis. The situation to be observed, and its actual dimension, should be clarified; the extent to which social context is to be permitted should be specified. However, as yet, there is no standardised procedure applying to procedural tools.

Conditions of Observation

Observation may be distorted by a number of factors—prejudice, haste, little knowledge and experience, conservatism etc. In order to have a scientific observation, all these possible errors should be cautiously guarded against. The observation should be careful, minute and patient. One should also guard against wrong observation (malobservation). Wrong observation arising out of physical causes has to be avoided by all means. The observer should be properly trained, and be capable of using his methods and tools properly. He should have sufficient knowledge and experience in the area of his investigation. The selection of relevant facts for the purpose of observation is also an important condition for making sound observation.

Observation requires, generally, three conditions to be satisfied: intellectual, physical and moral. The desire to know and unfold the truth is the main prerequisite for observation. The reason and explanation of phenomenon come from intellectual faculty and introspection. Perfect physical capability and sound sense organs are essential for proper observation. The required moral condition is related to unbiasedness and impartiality. Subjective inclination, conservatism, superstitions, habits etc., should be entirely given up while making observations. There should be no pre-conceived notion or bias about that which is being observed for finding out the truth.

Fallacies of Observation

The fallacies of observation are of two types: *the fallacy of non-observation* and *the fallacy of malobservation.* The fallacy of non-observation is committed when the relevant facts are overlooked or neglected i.e., when some of the relevant facts remain outside the observation. There may be the overlooking or neglect of instances and/or that of the essential circumstances. We may overlook an instance which should have been observed because of its relevance. This may be due to superstitious habit, pre-conceived notion etc. The overlooking of necessary circumstances may be due to the inadequacy of knowledge and/or unnecessary haste. The fallacy of malobservation arises out of the wrong interpretation of sense

perception. When observation is mixed with unconscious inference, malobservation is caused. Malobservation is due to misinterpretation of our perception. It is the observation of something, which makes it different from what it is, actually. For instance, at night one may observe a rope as a snake.

Observation in Social Sciences

In social sciences, observation is one of the important methods of acquiring knowledge. The observer has to take special care to ensure that his observation is more or less accurate. The observation of human behaviour is difficult in social sciences. A human being does not behave very often in the same way under similiar circumstances. And different human beings behave differently under a similar situation. Human behaviour or choice is highly volatile. There cannot be any single law or tendency to explain human behaviour. Human behaviour may be both rational and irrational, and these may be combined in the matter of personal volition or action. In social sciences, the technique of observation and the method of measurement are not ideally developed. As a result, observation is, to some extent, bound to be incomplete and inaccurate. Particularly, in social sciences, there is no standard procedure yet evolved to construct or apply procedural tools.[3] In order to have both outside and inside views, it is necessary, in social science research, to resort to both participant and non-participant types of observational techniques. However, in social science research, observation plays a more important part than experiment.

Since human beings may behave indifferently when they are aware that they are being observed, it is better to keep the observed persons unaware of observation. In order to find out the actual or normal behaviour of persons, the observer may be a participant without revealing his identity. However, participation may lead to the loss of objectivity. This, then, should be guarded against. But that does not mean that non-participant type of observation is not scientific. The operability of participant observation depends on the situation and the problem at the disposal. The Behaviourist School of Psychology lays great emphasis on this type of observation as the best way to know human behaviour.

Experiment

When observation is arranged and controlled, it is experiment. In experiment, the phenomena are artificially reproduced; but the conditions under which they are produced are selected and already arranged. Then observation takes place. In experiment, we put questions to Nature for eliciting answers relevant of our purpose.

3. *ibid*, p. 177.

Distinction between Observation and Experiment

Observation is regulated perception; but experiment is controlled observation. In simple observation, the phenomenon to be observed is supplied by the Nature, whereas in experiment, the phenomenon is artificially produced. Observation means the finding of fact, but experiment means the making of fact. In Observation, therefore, the circumstances of the phenomenon are beyond our control; whereas in experiment, the circumstances of the phenomenon are within our control. Observation, however, is not completely natural, since we have to make use of artificial technical instruments; and experiment is not completely artificial, as we have to make use of natural power for the observation of the created phenomenon. Prof. Stock observes that observation is passive experience, while experiment is active experience. In observation, we watch the natural events as they are without attempting to control them; but in experiments, we become more active in creating the conditions for the phenomenon to occur, and in controlling the circumstances of the phenomenon. However, observation is not wholly passive, since it requires active mental faculty to select the relevant facts. In fact, observation and experiment are, in a way, facets of the same process of study of events, finding their causes and explaining their occurrence. Observation is like a genus having two species—simple observation and experimental observation. In these two cases, events are studied, natural power is utilised, artificial instruments are used and mental and physical activity is shown. Therefore, "observation and experiment do not differ in kind but they only differ in degree."

Advantages of Observation Over Experiment

1. Experiment is not possible in all cases; but observation can be carried out for all possible cases. Experiment is sometimes impossible or dangerous, but observation is not so. The scope of observation is much wider than that of experiment.

2. The preparation for experiment are dependent on observation. Prior observation is a condition for experiment. Observation may go without experiment, but experiment cannot go without observation.

3. In observation, we can have reason and argument from cause to effect, and from effect to cause. That is, the argument may be forward or backward; but in experiment, it is not so. Experiment proceeds from cause to effect. In observation, thus, we can find out the cause of the effect or the effect of the cause; but experiment only unfolds the effect, the cause being given.

Advantages of Experiment over Observation

1. In experiment, it is possible to isolate the factors involved

in a phenomenon; but in simple observation, this cannot be done. This can be done by making one factor variable, and other factors constant. In simple observations, since the conditions are not controlled, factors cannot be varied and made constant systematically.

2. In experiment, we can easily reproduce the phenomenon and vary the circumstances indefinitely. But in observation, we have to depend on Nature for the supply of appropriate instances. In experiment, we may have as many instances as possible; but in observation we have got to wait for a favourable opportunity and depend on the mercy of Nature.

3. Since in experiment the circumstances are within our control, things can be examined with sufficient calmness, care and poise. But in simple observation, we may have to be in haste, lest the phenomenon disappears very quickly. The observer has to wait but Nature does not, in simple observation.

Experimentation in Social Sciences

Experimentation is extensively used in physical sciences; but its application is greatly limited in social sciences. Experiment cannot be perfectly carried on in sciences which deal with human behaviour. The behaviour of human beings cannot be controlled; and human behaviour cannot be subjected to laboratory test. The main features of experimentations, e.g., the isolation of factors, replication of the experiment and quantitative measurement, may be made applicable at least in some of the social sciences. In social sciences, laboratory experiment is rare; and there are difficulties in appreciating and observing circumstances. The hypotheses cannot be adequately tested. But some of the difficulties in experimentation in social sciences can be avoided by developing better tools and by improving the techniques.

Stages of Experimentation

The first stage of experimentation using trial and error method is applicable to a number of socio-economic problems. However, this stage is only a groping stage. This stage can be improved by controlling the situation, defining terms and concepts, and by introducing scientific measurement. In social sciences, field experiment is being utilised with considerable success. Here, "the investigator manipulates one independent variable in a real social setting." Experimentation in social sciences faces non-homogeneous and complex units where observation cannot be controlled. The difficulty of isolating disturbing elements puts a hindrance to the conditions of control. But despite the drawbacks, experimentation has become an essential part of social sciences. Prof. M.E. Brunk observes that, "controlled experimentation has established itself as

a valuable tool in agricultural economics."[4]

The Steps in Experimental Techniques

The first step in the application of field technique relates to the mentioning of specific objective, selecting the problem, design and method. The hypothesis, at this stage, should be stated explicitly in general terms. The next step consists in setting up the field experiment. The factors to be controlled must be assessed; the co-operation between the researcher and the subject must be set up; and scouting for information is required before any choice regarding setting is made. The next step is the choice of experimental design regarding its size, material, control groups etc. The choice of material should be based on the criterion of maximum possible accuracy. The basic problem of design relates to control. Control and experimental groups should be matched on all important factors. In cases where conditions cannot be standardised, the significance of the factors can be deduced through various devices of measurement, such as trends, extrapolations etc. Control is necessary to reduce variations. In some experiments, some variables may be eliminated. Undesired variations can be reduced by standardisation. A good experiment tries to maximise standardisation. The size of the controlling and experimental units, however, should be fairly small for easy handling.

The social sciences have developed a number of devices for improving experimentation. One such gadget aiming at improving measurement, plotting trends and extrapolating observation is sociometry. The social measurement technique is now attempting to give greater exactitude to the relationship between social referents and concepts. Attempts are being made to numerically measure the behaviour, to quantify the qualitative data, through improvements in the technique of measurement.

Limitations of Experimental Technique

1. The singling out of one social factor in a phenomenon for the purpose of measurement is difficult, because in any event so many factors are intermingled.

2. Control of factors sometimes is not possible, because some factors may be unknown and uncontrollable.

The difficulty may be overcome by randomisation which seeks to neutralise variations due to extraneous factors. But at the last stage of the experiment, the sample may not remain truly random. It is better to select several random samples as experimental and control groups. Selectivity vitiates the random character of the

4. M.E. Brunk, "Sample Surveys and Experimental Design", *Journal of Farm Economics*, May 1955, p. 232.

sample. One solution here is the adoption of the control group technique.

3. There are difficulties in interviewing the control groups. The remedy may be found in matching the control and experimental groups on as many points as possible.

4. The determination of the required level of significance of the differences between the experimental and control groups, is also fraught with difficulty. What difference can be taken as significant ? There is the problem of value judgement. But the scientific criterion is the determination of the statistical test of significance. However, this requires a reliable and valid socio-metric scale.

5. Another theoretical difficulty relates to replication. In social science research, the scope for repetition is very small. Experimental studies are new, controversial, expensive and not thorough, in social sciences.

However, despite these limitations in social sciences, the scope of experimentation can be further increased and improved. The sensitiveness of experiments can be augmented by neutralising bias through random choice, by increasing the area of experiment, by repeating experiments on a longer scale, by improvement in quantitative technique and by refinements of technique. The interpretation can mainly be tackled by introducing statistical devices and, observation can be made more sensitive by the introducion of greater uniformity in material. But when all is said and done, it must be admitted that the technique of field experiment in social sciences is still in its infancy.

Some Experimental Designs in Sociological Research

Prof. F.S. Chapin has suggested three experimental designs in sociological research.[5] They are discussed below :

1. *Cross-sectional design* seeks to analyse the current problem by making controlled comparison through the procedures of selective control. It is an analysis of association between different social groups. An attempt is made here to make the experimental and control groups homogeneous, by the matching of measurements on selected factors. There may be identical matching, or there may be the equation or frequency distribution on a particular aspect or feature. The applied technique seeks to find out the statistical relationship by the computation of correlation co-efficients and the analysis of breakdown and of partial correlation. The "analysis of association by cross-sectional design forces us to handle the data, and the matching process adds to our store of direct knowledge of the factors in the problem."

2. The *Projected design* tries to analyse the future from the

5. F.S. Chapin, *Experimental Designs in Sociological Research.*

present. This design is utilised to suggest the achievement of desired ends with respect to the social programmes. This can be done by means of a technique which separates the means-ends scheme from the impersonal cause-effect relations. On the basis of a set of assumed antecedent-consequent relationship, successive events can be explained. This design is a kind of association between factors having probability of occurrence. In this design, the factors are quantitatively elaborated first ; then the time lag, if any, between the appearance of a factor and the reaction, is studied ; and finally the concept of mean score on a reasonable scale is introduced to measure adjustments. However, social events cannot always be explained in terms of design, purpose and planning. This is so, because events are caused by so many factors—simple and complex, known and unknown.

3. The *Ex-post facto design* attempts to trace out the prior cause from the present problem. It is an analysis from the present to the past. The design consists of the same individuals at the present and at some prior period (or, the comparison of population of an area in the present or in the past). Here, the ordinary technique of induction is followed. The operations are simplified by control, through matching of several independent variables which are related to dependent variables. In this design, the purpose of observation under conditions of control is to isolate the relationship between the main causal independent variable which is considered as the effect. However, in this design, the freedom of application in method and technique seems to be restricted because the facts are to be collected from the available past and present records only. Furthermore, the choice of causal and control factors also appears to be restricted because of the presence of only a handful of causal factors in this design.

6

INFERENCE

Meaning, Nature and Type

Inference is the justified logical process of passing from one proposition to another proposition. In an inference, generally, more than one proposition is required. When inference is translated in terms of language, it is called argument. In an argument; the given proposition or propositions are called the premise; and the result, which is drawn out of the given propositions, is called the conclusion. Inferences are broadly classified into two types : deductive inference and the inductive inference. Conclusion in the deductive inference cannot be more general than, or cannot go beyond the premises; but conclusion in inductive inference is more general than, or goes beyond, the premises. Deductive inferences have been reclassified into two categories : immediate and mediate. In immediate inference, conclusion logically follows from only one premise. In this inference, the meaning of the single proposition is made clear. Since immediate inference is a type of deductive inference, the conclusion here cannot be more general than the premise. In mediate inference, the conclusion is drawn, logically, from more than one proposition. When there are only two premises in a mediate inference and the conclusion follows automatically from them, such a type of mediate inference is known as syllogism.

Is Immediate Inference Inference ?

The traditional logicians, generally, at least a good many of them, like Mill, Bain etc., do not regard immediate inference to be inference proper. In the case of immediate inference, the conclusion does not reveal any new truth, but it only contains what is already asserted in the premise. The fact of the conclusion is either the very same fact or part of the fact asserted in the premise (i.e., original proposition). Therefore, in all these cases, there is not really an inference. This justified opinion of Mill is also supported by Prof. Bain. According to Bain, in immediate inference, there is no transition from a fact to some different fact :

but there is merely the transition from one wording to another wording of the same fact. Unless there is the transition from a fact to some different fact, there cannot be any inference in the proper sense of the concept.

However, in immediate inference, the step from the premise to the conclusion is a minor or small step, but nonetheless it is not correct to point out that there is no step at all. Immediate inference spells out clearly the full implication of the given proposition, by making explicit what is implicitly referred to in the premise. It is true that the given or original proposition is known, but its full meaning or implications may not be known. Thus, immediate inference begins from something which is known and given, and it brings out something which is new and unknown.

Immediate inference may be of various types. Some of them are discussed below :

Conversion : It is a type of immediate inference in which there is a right transposition of the subject and predicate of a proposition. For instance,

No man is perfect (convertend)
No perfect beings are men (converse)

By conversion, A proposition leads to I; E leads to E; I leads to I; but O does not lead to any conclusion.

Obversion : It is a type of immediate inference where there is an alteration in the quality of a given proposition, the meaning remaining the same. For instance,

All men are mortal (obvertend)
No men are non-mortal (obverse)

By obversion, A leads to E; E proposition leads to A; I leads to O; O leads to I.

Let us consider an example,
Virtue is good
Vice is evil.

It is a case of material obversion. This inference is justified only on the basis of the matter of the proposition. Bain says that this type of inference is not of formal type. Here, the rules for obversion are not followed. It is, therefore, a material inference based on knowledge and experience, and does not come under the purview of deductive logic.

Oppositional Inference : It means the inferring of one proposition from another. There are four main types of opposition; e.g.,

subaltern, contradictory, contrary and sub-contrary. They are discussed below :

Subaltern : It is the relation existing between two propositions which have the same subject and same predicate but which differ in quantity only.

Rules : If the universal proposition is true, the corresponding particular proposition is also true, but the converse is not true. (II) If the particular proposition is false, the universal proposition is also false, but the converse is not true.

Contrary Opposition : It is the relation between two universal propositions which have the same subject and same predicate but which differ in quality.

Rule (1) If one proposition is true the other is false, but not conversely.

Sub-contrary Opposition : It is just like the contrary opposition, but the only difference is that sub-contrary relation holds only between two particular propositions.

Rule : If one proposition is false, the other is true, but not conversely.

Contradictory Opposition : It is the relation between two propositions having the same subject and same predicate, but differing in both quantity and quality.

Rule : The truth of one proposition implies the falsity of the other, and vice versa.

Implication and Inference

Implication is the logical consequence or relation between propositions. The test as to whether there is a logical implication between one proposition and the other is the impossibility of the former being true and the latter being false. That is, if the proper proposition is true, the latter proposition cannot be false, if there is a valid logical implication. In the case of valid proof, the conclusion is implied by the premises. There is a valid inference of one proposition from the other, if there is an objective relation of implication between the first and the second propositions. Inference is a temporal process but implication is an objective relation between propositions. Therefore, they should be distinguished from each other. Even if the process of inference from one proposition to another is not known, an implication may still hold very well. To be valid, an inference requires that there should be an implication between propositions. "The being of an implication does not depend upon the occurrence of the psychological process of inferring."

Probable Inference

Probable inference arises out of partial or incomplete evidence. A probable inference is true in most of the cases. The probability of an inference may be increased by bringing in additional evidence. Since induction or generalisation is often based on limited number of cases, it can only give probable inference. Another form of probable inference is the presumption of fact. Presumption of fact leads us to deduce a fact which cannot be directly observed. For instance, if anybody is feeling giddiness, we may presume that he has nervous strain. But from the point of necessary implication, the inference in this case is invalid. For, here, the observable fact may be due to other causes. Therefore, our generalisation here is only a probable conclusion, because in series of possible inferences, the conclusion is true with a considerable relative frequency when the premise is true. When a theory is probable and cannot be verified, we can, in some cases, verify the propositions which are the logical consequences of the theory.

Probable inferences have the following essential characteristics :

1. A proposition is probable in relation to other propositions which can be taken as the evidence for it.

2. Probability is an objective consideration and not a subjective feeling.

3. The very meaning of probability entails relative frequencies. The theory is probable when the argument for it belongs to a class of arguments where the relative frequency (r) of the truth of the conclusion, when the premise is true, is not necessarily 1.

4. The same proposition may have different degrees of probability in accordance with the supporting evidence.

5. Evidence may have varying probability, and the evidence which has greatest probability is generally chosen.

6. Although the measure of probability is the relative frequency, the definite numerical value of probability is unknown in most of the cases.

Paradox of Inference

On the one hand, it is said that the conclusion must follow from or must be contained in the premises; and on the other hand, it is said that conclusion must be different (something new) from the premises. This is then a paradox.

However, a psychological novelty is different from a logical novelty. An inference may be quite valid even though the conclusion is quite familiar. A conclusion may not be quite familiar if the argument has a long series of inferences. Logical novelty means

the logical independence of the conclusion from the premises. In a valid argument, the conclusion cannot possess logical novelty. When we say that the conclusion is contained in the premise, we mean that the conclusion is implied by the premise. The inferences are valid if there are objective relations of implications between propositions. Inferences are generally made, but implications are discovered. We may distinguish between the conventional meaning of a proposition, and the proposition that is implied. The conventional meaning of "All men are mortal" is that the class of men is included in the class of mortals. This distinction is helpful in solving the paradox of inference. Ordinarily, the conventional meaning of the premise is present very much in the mind and that of the implied prepositions may be absent. Therefore, when the latter are found to be implied by premises, a sense of novelty comes in the mind. From the point of view of the relations between conventional meanings, the meaning of the implied propositions is always contained in the meaning of the premises. After all, the relations of implications hold good not because of the empirical truth of the premises, but because of the logical relations between the premises and the conclusion.

However, inductive inference must conform to the rules of valid inference. Induction and deduction are not opposed as forms of inference. The actual contrast is not between deductive and inductive inference, but between inferences which are necessary, and inferences which are probable. This is so, because the evidence for universal propositions cannot be more than probable.[1]

1. Cohen and Nagel, op. cit., p. 279.

7

CLASSIFICATION, DEFINITION AND DESCRIPTION

Classification

Classification means grouping together of things on the basis of a particular trait, or similarity. The common similarity, which is the basis of classification, is found through mental grouping, together of things and not always through physical grouping.

Classifications may differ in their logical and scientific significance because various traits differ to a great extent with respect to their fruitfulness as principle of organised knowledge. Some traits may have higher logical value than others for the attainment of systematic knowledge or science. It is important to pick out that trait of the objects studied which can give a significant revelation of their nature. But there is no definite rule for doing so. It depends to a considerable extent, on the knowledge and experience of the person doing it. Formal logic is helpful in that it can define the objects and traits and can permit consequent systematic deductive reasoning.

Natural and Artificial Classification

The classification which is based on the nature of things is called natural classification; and other classifications are called artificial classification. The distinction is based on the purpose of classification. The purpose of natural classification is to know the nature of things but the purpose of artificial classification is to serve some practical human needs. The objective of artificial classification is practical.

All classifications can also be said to be artificial, in the sense that the traits are selected on the basis of which the classification is made. Artificial classification is sometimes natural because the attributes belong to the objects classified. Natural classification is also sometimes artificial, because the former is man-made and serves the purpose of some practical, human needs. Artificial classification may not be significant in the sense of providing useful clues

for systematising our knowledge about the things. But the attributes of natural clasification are significant in the sense that they reveal more about the nature of things. With the advancement of knowledge, it is possible to discover points of similarity behind apparent differences, and points of difference behind apparent similarities. However, with the advancement of scientific knowledge, it becomes possible to know more about the nature of things; and a new method of classification may be substituted for the old.

Division of Classification

Classification does not consist in the grouping of things alone, but grouping of class as well. Individual things, having the same characteristics are called the "species," and different things having some common features are grouped into a "family". The families are combined into higher groups called "orders," and orders into "classes." A 'division' is nothing but the exhibition of various species in the same genus. Division means the breaking-up of classes into sub-classes. When division is considered with respect to the individual members, the process is called classification.

Rules for Division (or classification)

(i) The constituent species of the genus must exclude one another.

(ii) Every species in the genus must be considered.

(iii) A division must proceed at each stage upon a single principle e.g., in the case of professors, the subject-matters they profess.

However, these rules are only ideal, and as such, inadequate for the development of science. With the growth of knowledge, something new in the subject-matter may be explored; and classification or division may be made more exhaustive.

In Aristotle's dichotomous division, one cannot be sure that all the sub-classes have members. "The practical difficulty of finding significant principles of division still remains." Be that as it may, at the early stage, all sciences remain classificatory; and grouping of objects may be taken up with a view to having mastery over the subject-matter.

Nature of Classification

(i) Classification is mental grouping of phenomena or facts.

(ii) Things are classified according to their resemblances or differences.

(iii) Classification is done for some definite purpose.

Purpose of Classification :

1. The general or scientific purpose of classification is to extend the area of knowledge.

2. Classification may also be made for some special advantage or purpose, e.g., a librarian classifies books for facilitating the finding out of books.

Classification as a Method of Science

1. Classification in science is done for extending the horizon of knowledge.

2. Classification in science has become more and more objective.

3. In science, for classification, more attention is paid to the nature of the thing.

4. Classification is a means to find out an order in Nature.

5. Classification is the recognition of unity in diversity.

6. It is the first method in science.

7. It finds out objective relations among things.

Steps in Scientific Classification

(i) Firstly, on the basis of most important and essential points of similarities, the things are grouped and classified.

(ii) The things are then classified on the basis of similarities and differences.

(iii) The smaller group is classified into still higher groups, the higher groups are classified into still higher groups and so on. Thus, scientific classification is graduated upward.

Limits to Scientific Classification

(i) Classification proceeds from less general to more general.

(ii) Things which cannot be defined, cannot also be classified.

(iii) Marginal cases (cases having certain features of one class and certain other of a different class) cannot be scientifically classified.

(iv) It is only rudimentary. It cannot say why the classes are such as they are.

Uses of Classification

(i) Classification is similar to explanation. It gives a better understanding of the facts of Nature, and it increases the horizon of knowledge.

(ii) We can remember similarities or differences more easily. Thus classification is an aid to memory.

Classification and Description

They are closely connected. Description may be easy or difficult. In difficult cases, the qualities, processes etc., may be hard to describe. Quantitative consideration may arise in both classification and description—and the matter becomes difficult to handle. In that case, a science develops nomenclature and terminology. With these, description and classification become easier. In an ordinary case, a thing is first classified and then described.

Classification and Definition

Classification means the grouping of facts or objects into classes according to the most important point of resemblances. In definition we determine the essential quality of things. Thus, classification is based on definition. Individuals can be classified into groups when their essential qualities are known. But in artificial classification, it is not required. In artificial classification, definition is not important.

Definition

According to Aristotle, "a definition is a phrase signifying a thing's essence." By 'essence' he means fundamental attributes of a thing. A definition is the precise statement of the meaning of a word. A science works through languages which should be free from vagueness and ambiguity. Language is a system of symbols. The symbol stands for something. The symbols may be words or nonverbal signs. The purpose of definition is to make clear and precise what a symbol stands for or refers to.

Nominal and Real Definitions : A nominal definition is a resolution or agreement with respect to the use of a verbal symbol or word. Nominal definition is only a linguistic decision; it has got nothing to do with the nature of things. It is neither true nor false, and as such, it cannot be a proposition or premise.

Nominal definition helps in scientific enquiry by :

(i) economising time, space and energy and by making symbols clear, precise and simple.

(ii) making the familiar terms into somewhat unfamiliar and technical, because by doing so, irrelevant, emotional and accidental associations may be shed out and the process of deduction may be made rigorous.

A real definition expresses the precise nature of a thing which is being defined. Such a definition describes the essential nature of

a thing. The real definition of 'horse' should give the precise nature of horse. Essential nature consists of those features without which the word defined would not refer to it. A real definition may be a genuine proposition.

Definition of a thing incorporates two aspects of the thing—its genus and its differentiating features. Thus, the genus of a triangle is a figure, and the differentiating feature of a triangle is that it has three sides.

Rules for Definitions

1. A definition must give the essential features of the thing which is defined.
2. A definition must not be circular. It must not contain the subject which is to be defined.
3. A definition must be in the positive term (where it can be).
4. A definition must not be expressed in vague, ambiguous and figurative language.

Psychological Motive and Logical Purpose of Definition

Definitions satisfy the psychological desire to learn new things, to find convenient and short expressions for long ones, and to make the meaning of a word precise, clear and definite. The meaning of a word may be grasped with the help of synonyms, although synonyms do not have precisely the same meaning. But the common intention can convey the meaning of the word in a more or less precise manner.

Logically, definitions are helpful for finding the structure of the concept in order to make it definite for the purpose of systematic exploration of the subject-matter. According to Aristotle, "the basic premises of demonstrations are definitions." In the mathematical techniques, all real definitions are implicit. In logical techniques, real definitions appear as axioms. Axioms are prior to all theorems, but are not prior to the development of knowledge.

The distinction between nominal and real definitions is not very clear-cut. Conflicting attitudes towards religion, law and property could be minimised if precisely defined equivalents are found. The emotional associations of words may be reduced, and social science may be made more precise, if definitions are made clear and precise. A real definition involves two sets of meaning which are equivalent, if the definition is true.

Deductive and Inductive Definition : In deductive definition, we state the meaning of which is fixed. But in inductive definition, we try to determine the connection of a term by examining facts.

Inductive definition precedes deductive definition. Where examination of facts is not necessary, e.g , as in Mathematics, we use deductive definition. When, on examination, we come to know that human beings possess the attributes "animality" and "rationality", then we are employing inductive definition. Once the meaning is had, we employ the deductive definition that "Man is a rational Animal."

Substantial and Genetic Definition : A substantial definition is the description of the defined thing or term. It gives the substance or the essence of the term A substantial definition is the same as the real definition, because both point out the essential characteristics of the thing If we define a triangle as a plane figure bounded by three straight lines, then it is a substantial definition.

Genetic definition does not point out the essential characteristics of the thing, but it points out the way in which the connotation of a thing can be determined. For instance, it does not define a triangle, but simply states how it is formed. This definition is helpful for the formation of definitions. A genetic definition indicates the mode of the origin, for the formation of the thing, and thus, helps us in understanding the essential nature of the thing.

Material Conditions of Definitions : Material conditions are the procedures necessary for knowing the essential qualities of a term. They are the following:

1. The instance of the thing should be collected, then differing characteristics are excluded and common essential characteristics are to be taken. This is the positive method.

2. In order to know the essential qualities, we must know the opposite notions of things. For instance, in order to know the essential qualities of a solid, we may say that it has a fixed form. This is positive notion. We find that liquid or gases have no solid form. Hence, our previous finding is correct. This comparison with other objects is an opposite notion here. This method is the negative method.

However, positive instances are numerous and there are also marginal instances. Therefore, it is practically very difficult to apply these methods.

3. Definition by type is employed by certain logicians to eradicate the above difficulties. Type means a member of a class possessing the characteristic of that class in a marked degree. For example, a Chinese may be said to be a type of the Mongolian race. Thus, instead of describing the essential features of the Mongolian race, we simply refer to the Chinese. However, by this definition, the real difficulty cannot be avoided, because in order to know the type, we must have the knowledge of the essential qualities.

Dynamic Nature of Definition

A definition is an essential aspect of knowledge. In any science, a reference to the definition of terms will point out the progress attained by the science. Definitions represent the basic feature of scientific knowledge. At a particular point of time, the definition of a term may be adequate, but as new facts are developed and knowledge increases, the previous definition may be found to be inadequate or incomplete. All definitions in sciences may undergo changes. Thus, a definition is a dynamic concept. For example, economics is no longer defined as the science of wealth or money, but is defined as the science of product behaviour.

Theory of Predicables

This theory provides the logical basis of definition. It was originally put forward by Aristotle. It finds out the way in which the predicate is related to the subject in a proposition. The predicate is that which asserts something about the subject. Predicables are terms used for indicating the ways in which the predicate is related to the subject.

According to Aristotle, in certain cases the predicables are convertible with the subject (i.e., may be substituted for the subject). But in some other cases, the predicables are not convertible with the subject. In the former case, the predicate is the definition or the *property* of the subject. In the latter case, there are two possibilities: (i) the predicate may be contained in the definition of the subject, but is not completely convertible with the subject. In this case, it may be the *genus* or the *differentis* (ii) It may not be contained in the definition of the subject or it is not convertible with the subject. In that case, it may be an *accident*. Thus the predicate is related to the subject in one of the five following ways:

(a) Definition

(b) Property

(c) Genus

(d) Differentia

(e) Accidents

(a) *Definition*: It states the essential characteristics of the thing. It is a thing's full connotation or essence.

(b) *Property*: It is an attribute of the thing. It is derived from the essence. A property does not represent definition, but is associated with the thing which is being defined. For instance, animality is a property of human beings, but it is not the definition of human beings.

(c) *Genus and Species*: A genus is a class of things to which a particular subject belongs. It is an essential part of a definition. "Animality" represents a genus to the category of living beings.

When a smaller class is included in the larger class, the small class is called a *species*. For instance, animal is genus and man as a subject class of genus is a species. A term may be genus in one context but species in another context.

(d) *Differentia*: It is a distinguishing feature of a thing by which a thing can be differentiated from another thing of the same category. "Rationality" is a differentia in human beings, because it is rationality which distinguishes man from other animals. A complete definition must state both genus and differentia.

(e) *Accidents*: It is a quality which is connected with a thing by chance. It is not a part of the connotation of the thing. The colour of a man is an accident, because it is neither the connotation, nor can be inferred from the definition.

Thus, a definition is a precise, clear, and explicit statement about the essential characteristics of a thing. In a definition, the defining expression must contain more than one word. A perfect definition must state differentia and genus.

Description

Description is the statement of essential characteristics of a thing. With the help of description, we can know the characteristics of a thing. Thus, grouping can be easily done. For scientific classification, it is essential to have a detailed knowledge of the things which are to be classified. Since the characteristics are not perfectly remembered for a long time, it is necessary to record description. When things are classified into various groups, the correct description of the nature of each class is required. The description is required to specify the common characteristics and particularly, the more important characteristics. The important quantitative differences of common characteristics between the things of the same class are necessary to record in description. The degree of common characteristics may vary from one thing to another even in the same category. These differences in degrees have to be described and known by a scientist. Since description requires the use of language, a science must develop its own nomenclature and terminologies. Thus, we find that description is relevant to classification.

Description and Definition

Description is a statement of property or characteristics of any term. Definition is the statement of connotation. 'Property' or 'attribute' is not the same as connotation. Property, however, follows from definition. Description includes every aspect, and as

such, it is broader than definition. Definition is only a very precise statement of the most essential attributes. Description is more general but definition is more particular. Description is not very precise; it is popular but not as scientific as definition. Definition is about a term; but description is about objects or events.

Limitations of Definitions

(i) The highest genus or broadest category cannot be defined.

(ii) The terms, representing unique features, that cannot be connected with other things, cannot be defined. For instance, "sensation" cannot be precisely defined.

(iii) The terms having no connotation cannot be defined.

(iv) Terms representing classes of events or objects can only be defined. Thus, individual objects cannot be defined.

8

EXPLANATION AND MODELS

Meaning

This is essentially the same kind of reasoning as interpretation.[1] Explanation is the mental process used for clarification of understanding. Explanation is used when there is complexity or perplexity about something. It is the mind which determines perplexity and clarity. The necessity of explanation and the explanation itself are entirely the feelings of mind. Perplexity generates dissatisfaction and uneasiness in mind, while the clarity of understanding brings a sense of satisfaction and ease of mind. The urge to explain away things and to have clear understanding about matters, is a universal human urge which requires to be fulfilled. Curiosity leads to knowing and to know clearly, explanation becomes a necessity.

Understanding is the basis for explanation. But understanding can only be made through the process of relations between facts. If one is unable to find out the involved relations, one cannot understand the things. Understanding is to be made through mind by properly relating together the involved facts. A fact is anything that there is, or can be conceived of. Perhaps more important than finding out facts is the finding out of relations betwen facts, because facts themselves are not so crucial for explanation as relations are. Once the relations are discovered and understood properly, the facts can be shown to be an integral part of the system or order. A system implies an arrangement in which things are related together in a particular cohesive pattern. Judged in this way, every science is nothing but a system. Since explanation discovers the position of the thing explained in the system, it becomes a *sine qua non* for any science. As a system of knowledge, science seeks to discover an actual order in Nature which consists of various objects. Explanation, therefore, would correspond and help the process of systematisation of knowledge taken up by

1. Goode and Hatt, *Methods in Social Research*, p. 355.

science for facilitating the discovery of order in Nature. Knowing, as we have pointed out, entails explanation; and once we come to this stage, we have science. However, explanation is implicit in the universe of formal relations as well as in the universe of matters of fact. Logic is so fundamental to explanation that the Greek philosophers named different material sciences in terms of logic, e.g., geology.

Description and Explanation in Science

An opinion is generally expressed that science is mainly concerned with description and not with explanation. That is, a science should describe whatever is observed and it should not bring in the personal insight by way of explanation. This implies that the business of science is to investigate as to how a phenomenon happens and not as to why it happens.

There are, of course, arguments for this conservative attitude towards science. Explanation, more often than not, involves personal prejudice, likes and dislikes. There is a tendency on the part of people to explain natural phenomena in the same fashion as they explain their own personal actions and problems. Thus, explanation often becomes anthropomorphic, and not impersonal. This is one of the reasons why explanation is not considered to be the main function of a science. Ordinarily, explanation is looked upon as an action to some purpose or motive. As soon as the motive or purpose is found out, the action is explained finally and nothing further is called for. Therefore, the finding out of the purpose or motive becomes the main task of enquiry for explaining the natural phenomena. Thus, drought, diseases etc., are explained as the punishment imposed by God on people for their wrong actions. The purpose, of course, is realised at the final stage of an arrangement or process. Unless the final outcome of the entire activity or process is known, the purpose behind it cannot be ascertained. The purpose is, therefore, the final cause. Explanation in terms of the purpose is called the explanation with reference to final cause. But proper explanations can unfold various aspects of the phenomenon studied, e.g., where the phenomenon happens, why it happens, who is responsible for it, when it happens and how it happens, and so on. But it should be noted here that while spelling out the different aspects of a phenomenon, explanation has to be in sympathy with description.

Modern science always does not explain away things with reference to final causes, except under certain compelling situations. But it is not justifiable to say that science only describes and does not explain. A science starts with the particular but it is not concerned essentially with the particular, but with the general. Predictability is one of the most important functions of a science. A scientific law cannot be said to be descriptive of the observed

cases alone. It does not restrict itself to the observed cases, but it is extended to the unobserved cases also which are necessarily infinite and indefinite. Braithwaite has rightly pointed out that, "the predictive function of a scientific law would be ignored if the function of the law were taken as being purely descriptive."[2]

Unless the science offers explanation, we would not be in a position to appreciate even commonly known facts. There is no clearcut distinction of apple-pie order between what is observed—the thing that there is or that can be conceived of, and what is contributed by science in its own way by way of interpretation, explanation and systematisation. Explanation and interpretation are involved even in what appears to be the direct and immediate knowledge of an object through sense impressions. It is, therefore, not right to observe that the main task of a scientist is to describe the observed facts as they are, without any attempt to explain them. The proper meaning of a fact becomes clear with the help of proper explanations. Without explanation, facts remain merely dumb, barren and useless pieces of scattered information. "We can claim indeed that we 'see' the fixed stars, the earth eclipsing the moon, bees gathering nectar for honey, or a storm approaching. But we shall be less ready to maintain that we simply and literally see these things, unaided by any theory, if we remember how comparatively recent in human history are these explanations of what it is we see . . . the objects of our seeing, hearing, and so on, acquire meaning for us only when we link up what is directly given in experience with what is not. This brilliant white spot of light against the deep-blue background—it has an incommunicable quality; but it also means a star many light-years away."[3]

Types of Explanation

Explanation can be categorised into the following types:

(1) *Evolutionary Explanation* : This is a type of explanation in which a particular thing is explained by finding its place and position in the whole process of evolution. If a skeleton of an animal, for instance, is found under the earth, the anthropologist will try to understand the nature of the skeleton. He will provide explanations to support his view that the skeleton belongs to a particular type of animal. But he can tell this by classifying the animals and their skeletons. However, the skeleton may be similar to that of another type of animal, but the skeleton may not be so strikingly similar as to be certainly included in that type of animal. Under these circumstances, what is done is to trace its place as a link in the concerned process of evolution. This particular type of study of the process of evolution may be considerably helped by the

2. R.B. Braithwaite, *Scientific Explanation*, p. 348.
3. Cohen and Nagel, *An Introduction to Logic and Scientific Method* (abridged edn.), p. 10.

explorations in the field already made by anthropology. By investigation, it may be found that exactly such a structure of the skeleton fits in with the skeleton of the dinosaurs at a particular stage (say 500 years back) of evolution of the skeleton of dinosaurs, which had already been definitely traced. Thus, the obvious explanation would be that the skeleton which has been found is the skeleton of dinosaurs which existed some 500 years back. The basis of this explanation is the link provided by a certain series of evolutionary process.

(2) *Classification* : Classification itself is a type of explanation. Classification implies the finding out of relations between the things classified. The finding out of connecting relations between facts is known as explanation. Thus, explanation is obvious in classification, although this type of explanation is inadequate. If we come across a snakelike thing, we may not be able to explain it immediately unless we know its name and nature. However, by noticing its feature, we can classify it as a reptile. This classification then, provides at least an elementary explanation Here, the basis of explanation is the class to which the object belongs. Similarly, a class can itself be a sub-class of a large class.

(3) *Concatenation* : In this type of explanation, we trace out the intermediate steps by which the two concerned facts become related. The meaning of concatenation is linking together. For instance, it is found that water becomes cool very quickly in an earthen pot. Here, the explanation would take the form of tracing the intermediate factor of continuous evaporation of water which oozes through the pores of an unglazed pitcher, that makes the water cool.

(4) *Laws* : It is a general practice that a thing which is to be explained is fast related to the established law or laws that are relevant. Since by definition laws are the statements of uniformities, it is possible to find in laws a certain uniformity, system, order or regularity. The thing is then explained by discovering its position in the system or order of relations as suggested by the law or laws. For instance, inflation is explained by discovering the place of products in the system or order of relationship between demand, supply and price as suggested by the laws of demand and supply. Ultimately, it may be explained that inflation is due to either increase in demand, supply being fixed (or demand growing at a less than proportionate rate), or increase in demand; supply being lower or, demand remaining fixed, supply being very very low.

(5) *Induction* : Induction is also a type of explanation. In induction, we pass on from particular to general, from observed to unobserved. What we find true of observed, we generalise for unobserved, the nature of things remaining the same. This generalisation regarding the unknown passage is itself an explanation.

Generalisation means the indication of uniformity, order or system where objects are related together.

(6) *Teleological Explanation* : Where explanation of a phenomenon is provided with reference to the final cause or purpose, we have teleological explanation. This type of explanation was mostly used by Aristotle in his analysis of politics. Where human actions are involved, such an explanation is not used in physical sciences, it nevertheless has relevance in the analysis of some biological phenomena.

(7) *Theory* : Ordinary laws are explained by the help of more comprehensive laws or by theorising (construction of theories). In this type of explanation, one has to discover the place of law in a theoretical system or order. The process of discovery of laws from facts, and theory from laws, entails explanation. Facts can be explained by other facts or laws (which in themselves are facts). Ordinary laws can be explained by demonstrating that they can be deduced from more comprehensive laws of a theoretical system. This process of explanation or analysis is called the process of subsumption or bringing under. The facts are brought under laws and ordinary laws are brought under more comprehensive laws. This is the way in which a science is constantly engaged in the study of Nature. However, at certain stages of scientific enquiry, some super-laws may be encountered which cannot be explained satisfactorily, since they cannot be shown to be deducible from some other laws. Thus, science faces problems and doubts raised about the capability of science as an omnipotent system of explanation. When more knowledge is accumulated, such unexplained laws may be explained. However, "there is no ultimate end to the hierarchy of scientific explanation, and thus no completely final explanation."[4] After all, a scientist's last explanation is not his final explanation.

What is a Model ?

A model represents a structure. In formal logic, it has been used for the set of entities which satisfy the axioms of logic. A model also means a replica. It also means an order where different variables are inter-related. Models are used for the purpose of explanation. The similarity of relation between the model and a system modelled is called *isomorphism*. The models used in sciences are called *iconic models*. Such models represent some imagined things or real things or a process. Their function is to extend our understanding regarding a problem. A model in theoretic science contains some of the features of both logical and replica models.

4. R.B. Braithwaite, op. cit., p. 347.

Analogy and Model

Sometimes analogy becomes the basis of a model. History proves that analogies provide the building block for theoretical ideas. A number of scientists admit that models play an important role in the construction of new theories. For example, Black's experimental discoveries regarding heat were suggested by his conception of heat as a fluid. Similarly, Huygens developed his wave theory of light with the help of sound as a wave phenomenon. Fourier's theory of heat conduction was constructed on the analogy of the known laws of the flow of liquids. Models serve as a guide for setting up fundamental assumptions of a theory as well as a source of suggestions for extending the application of the theory.

Maxwell explained the ways in which analogies can be exploited in science. According to him, physical analogy reflects the partial similarity between the laws of one science and those of the others. He regarded analogy as a useful artificial method for the solution of a certain class of problems. He used the analogy between the theories of gravitation and theory of heat conduction.

Maxwell classifies analogies into two broad types : Substantive and formal analogies. In substantive analogies, a system of elements possessing the known properties is taken as a model. The various atomistic theories of matter illustrate the use of this type of analogy. In the formal analogies, we use a structure of abstract relations. Mathematics frequently employs such formal analogies.

Purposes and Sources of Models

Models are used for the following purposes :

1. They enable certain inferences to be drawn from given facts.

2. They express and enable us to extend our horizon of knowledge. This is called epistemological aspect of a model.

In the case of homoeomorphs models, the sources and subjects are the same. The models for which the source and subject are different are called paramorphs.

Types and Functions of Models

Scientific Models are utilised to increase our knowledge and to explain many phenomena. A scientific model is a statement of reality. The statements may be factual or theoretical or law-like.

Here are mainly the following types of models :

1. Iconic Model
2. Analogus Model
3. Symbolic Model

The *iconic models* are large or small scale representations of states, objects or events. *Analogous models* are based on familiar analogies. The slide rule is a familiar analogue in which quantities are represented by distances proportionate to their logarithm. In *symbolic model*, the properties of the things represented are expressed symbolically. Every equation is a symbolic model. However, Iconic models are most difficult to manipulate for purposes of determining the effect of changes on the real things. The symbolic models are the most abstract and general. They are also easiest to manipulate. A scientist uses iconic models and analogues as preliminary to the development of symbolic models.

Models and Hypotheses

Hypotheses serve as models in a theoretical science. According to Hertz, "Hypotheses are pictures or models which we make for ourselves of certain phenomena or groups of phenomena in order to gain a better general view of them and to see them more clearly". A hypothesis is good when this picture or model does not merely represent correctly the characteristics of the particular group of experimental facts, but when it further exhibits characteristics which lead us to new facts.

Models in Theoretic Science

The models in theoretic science are dependent on some system which is familiar and intelligible. It is not applicable to the theory which is widely accepted and has become factual. The theoretic model carries with it "surplus meaning" derived from the familiar system. Further developments and modifications of the explanatory theory may be suggested by the theoretic model.

The exploitation of model consists in investigating the neutral analogy. Such a model suggests modifications and developments of the theory which can be confirmed or refuted by evidence. The concept of paramorph model can be used in the analysis of theories of Natural Selection and Drude's Explanation of Electric Conductivity. A model explains causal mechanism which is very important for the understanding of a phenomenon.

9

ANALOGY, SAMPLING AND INDUCTION

Reasoning from Analogy

Analogy means similarity of resemblance. If we say that A and B resemble in intelligence, memory and studies, and A has stood first in the class, therefore, B would also stand first in the class; we are, in fact, arguing from analogy.

Some have argued that argument from analogy is a form of induction. Both analogy and induction are based on observation and both pass judgement from observed to unobserved. But in analogy there cannot be any effective generalisation. We cannot say surely whether B would stand first in the class or not. This is because we do not have knowledge that there is any positive correlation between intelligence, memory, studies and standing first in the class. But still, it must be pointed out, these qualities have something to do with standing first, or at least they are relevant.

In induction, generalisation is possible. The factor of enumeration and the factor of analogy together give the basis for good induction. As a matter of fact, even in induction by simple enumeration, analogy is present. Sometimes, analogy is presupposed in generalisation when we say that what has been observed to be true in some cases will also be true of all other cases having the same conditions, type and circumstances.

But analogy is sometimes too weak to lead to any valid induction. Let us take an example of an argument from an analogy.

A and B resemble in having a cycle, a watch and a camera. A has stood first in the class. Therefore, B will also stand first in the class.

This argument is absurd. These things have nothing to do with standing first in the class. But our earlier example is not absurd. This second example has no force, while the first has.

The proposition that "All men are mortal" can be expressed in two types of analogy: All things which have the signifying analogy "being human" also have the signified analogy "being mortal". In establishing a universal proposition, a signifying analogy is constantly conjoined with a signified analogy.[1] But these two analogies never exhaust the total positive analogy, nor even the known analogy. Universal propositions do not cover the total positive analogy. The part of the positive analogy not included in either the signified or the signifying analogy, is considered irrelevant. However, it is the objective of science to discover in observed things those parts of total positive analogies which are related invariably.

However, if we remember the first example given in this chapter, it can be easily understood that analogical reasoning is only a case of probable inference; and this depends on fair sampling.

Analogy and Scientific Induction

Analogy, according to Mill, is a kind of induction. In induction, there is a passage from known to unknown. This feature is present in analogy. Thus, analogy is a sub-division of induction. But since in analogy there is an imperfect similarity, analogy is regarded as a weak form of inductive argument. A comparison can be made between analogical reasoning and scientific induction.

1. In analogy, we proceed from particular to particular, but in scientific induction, we proceed from particular to general.

2. Scientific induction is based on the knowledge of causal connection (cause-effect relation), but in analogy, we do not get such knowledge.

3. The conclusion in scientific induction is certain, but the conclusion in analogy is only probable. This is so because in analogy there is imperfect similarity and hence, there is an element of doubt.

4. Analogy is the first step towards scientific induction. Analogy is a form of hypothesis. When it is proved, a scientific induction may be possible.

Factors Determining the Force of Analogy

Analogy is based on imperfect resemblance. The conclusion in analogy, therefore, is only probable. However, the degree of this probability may vary from zero to certainty. The force of the analogical argument will depend on the following factors:

1. *ibid.*, p. 287.

1. The greater the importance and the number of known resemblances, the greater is the force of the analogical argument. The resemblances should not be counted quantitatively alone; the importance of the resemblance is also to be taken into account. The more relevant the points, the more important they are.

2. The greater the importance and the number of known differences, the smaller is the force of the analogical reasoning. This is obvious because the basis of the argument is the resemblance between the things. If the things differ in many respects, then there would be less resemblances and analogy.

3. The greater the extent of knowledge about the things, the greater is the force of analogical argument. When the knowledge about the things is very comprehensive, it is possible to notice the important points of resemblances and differences.

4. The greater the number of unknown points as compared with the number of known points, the smaller is the force of analogical arguments. When the number of unknown points is greater, we cannot be sure in ascertaining the analogy between the things. Thus, our conclusion would be very uncertain and rough.

5. The force of an analogical argument depends upon the importance of the points of resemblances. Welton says that the force of an analogical argument, depends on the character of identity and not on the amount of similarity. "We must weigh the points of resemblances rather than count them."

6. The force of an analogical argument is expressed as:

$$\frac{\text{Resemblances}}{\text{Difference} + \text{Unknown Points}}$$

The numerator stands for the force of an analogical argument, the denominator stands for the weakness of analogical argument. So, if the value of the numerator is greater than that of denominator, the analogical argument becomes strong.

However, the force of an analogical argument cannot be calculated precisely through a mathematical ratio. In the above expression, the importance of resemblances is not taken into account. But this is more important. The importance, however, cannot be mathematically determined. Another difficulty is represented by unknown points. If the points are unknown, how can we know their numbers?

Misuse of Analogy (True and False Analogy)

A true or good analogy means an argument in which the

conclusion is drawn from the presence of essential resemblances between two things. The resemblances should be important and greater in number as compared to differences. The comparison should be comprehensive between two things.

A false or bad analogy means an argument in which the conclusion is drawn from superficial points of resemblances. In a false analogy, the argument is fallacious, careless and hasty. Due to the following reasons an analogy becomes false:

1. Superficial resemblances are taken into account between two things.

2. The important points of differences between the things may be overlookd.

3. Lack of comprehensive knowledge about the things.

4. Use of very remote simile and metaphor. These stand in the way of making important differences.

5. Confusion between the essential and non-essential points.

False analogy leads to the following fallacies:

(i) Fallacies arising out of confusion between the essential and non-essential points (i.e., overlooking important points of differences), e.g.,

"Plants, like men, have birth, growth and decay and death. Men possess intelligence; therefore, plants also possess intelligence."

This is a fallacy because the important differences between men and plants are overlooked. There is no essential connection between the points of the resemblance and the property which is inferred.

(ii) Fallacies arising out of improper use of metaphysical language, e.g., "The capital is the heart of the country, so if the capital of a country becomes very large, it is bad for the country, as the enlargement of heart is bad for the body."

(iii) Fallacies arising out of insignificant or unimportant resemblance between two things, e.g., "He will stand first in the examination, because his friend has stood first in the examination."

Here, the similarity is very superficial and unimportant.

Analogy and Fair Sampling

The principle of analogy is significantly connected with the principle of fair sampling. Observed instances are considered to be fair samples, because the observed instances are analogous to unobserved instances. Things are analogous in some relevant way

and different in some other ways. But whether things are analogous or different would depend upon the purpose for which an enquiry is undertaken. Human beings are different in various ways; and similar also in various ways. But when the purpose of enquiry is to find out mortality, an analogy is found among them in this respect. Whether a generalisation can be relied on or not depends on whether the observed cases are of the type which the generalisation is sought for or not. For being samples, the observed cases must be analogous to the cases which are being considered for generalisation. The observed cases must be relevant to the phenomenon being studied. A reliable generalisation, therefore, presupposes knowledge about the phenomenon, the type of case and the relevance of cases with the phenomenon. For a good generalisation, the number of sampling need not always be overwhelming. Mill remarks that often a very large number of verifying instances is insufficient to establish a generalisation firmly; while a few such instances are sufficient for generalisation.

A scientific induction is based on a type of study of the instances by which we can know whether observed cases can be considered fair samples or not.

Analogy sometimes becomes important and relevant for the reliability of the scientific generalisation. If the instances of the present phenomenon which is being studied become analogous to the instances of some other phenomenon which has already been studied and about which generalisation has been arrived at, then the generalisation of the earlier case can be used profitably to study the present case in hand. According to Cohen and Nagel, since electricity in motion presents certain striking analogies to the behaviour of liquids like water, the entire theory of hydrodynamics which deals with liquids may be extended to the phenomenon of electricity.

Generalisations on similar problems even in different fields may support each other. Hence, the reliability of a generalisation does not merely depend on the number of its verifying instances. Repetition of instances is valuable only if the subject is not homogeneous.

If the generalisation under enquiry can be connected with others, the ability to conduct fair sampling can be increased to a great extent; because in that case the verifying instances for a universal proposition can be gathered rapidly, since the generalisations would support one another. That is the reason why the deductive elaboration of hypotheses forms an essential part of the scientific method.

Role of Fair Samples in Induction

Inductive generalisations cannot always be conclusive. But scientific generalisation should have the highest degree of

probability. A scientist is not interested in multiplying the verifying instances for generalisation. In this connection, the observation made by Mill seems to be relevant. "Why is a single instance, in some cases, sufficient for a complete induction, while in others, myriads of concurring instances without a single exception known or presumed, go such a very little way towards establishing a universal proposition? Whoever can answer this question knows more of the philosophy of logic than the wisest of ancients, and has solved the problem of induction."

The problem is to find fair samples which are instances of that kind. Fair samples should be representative instances which can be used as evidence for the generalisation for which such instances are being collected. Ordinarily, the larger the number of instances, the greater is the probability of valid generalisation. In some cases, a single instance, observed under suitable conditions, may constitute a fair sample.[2] If an instance is highly representative, it may suffice and there is no need to add more instances to it. A large number of instances which are equal with one another in representation of that type, will serve the same purpose as anyone of them. A large number of instances may not always be fair samples, if they are not representative in character; and therefore, may not serve the purpose.

In fair sampling, the observed instances should cover as wide and as varied a range as possible within the type with which generalisation is concerned. A good sampling is based on the Law of Statistical Regularity and the Law of Large Numbers. Random selection of sample is the best representative of the population. There should be no element of human bias or prejudice in selecting samples. The Law of Inertia of Large Numbers indicates that large aggregates are more stable than small ones.

Positive, Negative and Neutral Analogies

The likeness between entities constitutes positive analogy. When two things resemble, in certain respects, it can be expected that they will resemble in other respects also. The strength of analogical argument depends very much on the positive analogy. An argument with positive analogy has a high degree of probability.

The unlikelinesses or differences between instances, processes and entities are called negative analogy. In some cases, negative analogy is not known. When an argument is based on negative analogy, it has a low degree of probability.

Sometimes, we do not know either likeness or unlikeness

2. A Wolf, *Text Book of Logic*, p. 289.

between two entities. This feature constitutes neutral analogy. In other words, in spite of analysis, a large number of qualities showing likenesses or unlikenesses between two instances remain unknown. These unknown qualities constitute neutral analogy. We infer neutral analogy from positive and negative analogies.

10

CAUSES

The Law of Causation

The law of causation states that every event has a cause. "Every phenomenon which has a beginning must have a cause". Nothing can come out of nothing. Nothing is the cause of an effect which is absent when the effect takes place. Similarly, nothing is the cause of an effect which is present when the effect does not take place.

The law of causation is considered as the formal ground of every induction. The objective of empirical science is to discover the laws which can express relations between the phenomena of Nature, that hold good universally. The method by which the universal propositions are arrived at for expressing laws is called induction. Induction is a process of generalisation. The formal truth of the inductive generalisation is guaranteed by the law of causation. It says that phenomena are related as cause and effect, and this relation expresses a uniformity of succession. Therefore, we can say that what has been observed to be the case so far, will also be the case in future. In other words, the causal connection holds good uniformly. The law of causation is like an axiom. We can deduce from the law of causation, certain principles such as the *canons of elimination* which form the basis of enquiry into the cause of a phenomenon. The canon of elimination is a test to find out the cause of a phenomenon. These canons can decide the formal truth of induction, and since these canons themselves are deduced from the law of causation, we generally say that this law is the formal ground of induction.

Law of Causation and Uniformity of Nature

According to Prof. Bain, the law of causation is a special form of the law of uniformity of Nature (uniformity of succession). By uniformity of Nature is meant that, in general, there is some definite order in Nature. The law of causation not only implies that every phenomenon has a cause, but also implies that the same cause

gives always rise to the same effect. The law of causation speaks about a special form of order—the order of the cause-effect relationship. The cause is the invariable antecedent of effect, and the effect is the invariable consequent of the cause. However, certain logicians argue that causation and uniformity of Nature are two separate and distinct laws. When we say that the same cause always produces the same effect, we are, in fact, taking into account the law of uniformity of Nature. When from cause-effect relationship of one phenomenon, we make generalisations for other phenomena, we are believing in the uniformity of Nature. The law of causation is alone the basis of scientific induction where generalisation depends on the discovery and proof of a causal connection. But the law of uniformity of Nature is the formal ground of both scientific and unscientific types of induction. These two laws together, however, can become the adequate ground of induction.

Definition and Characteristics of Cause

Cause is the sum total of positive and negative conditions. It is the entire aggregate of conditions or circumstances requisite to the effect. Qualitatively a cause is the immediate, unconditional and invariable antecedent of the effect, and quantitatively, it is equal to the effect.

Qualitatively,

- (i) the cause is relative to a given phenomenon which is called the effect.
- (ii) Causation implies that there is change in the existing state of things (an event in time).
- (iii) The cause is an antecedent to the effect—and the antecedent is invariable.
- (iv) the cause is the unconditional antecedent (requiring no further condition).
- (v) the cause is the immediate antecedent (immediacy follows from unconditionality. The term "immediate" should not be taken too strictly here).

Quantitatively,

- (i) the cause is equal to the effect (the matter and energy in the cause are equal to the matter and energy in the effect).

Conjunction (Composition) of Causes

Generally speaking, every cause has a distinct effect and

separate causes produce separate effects. However, in actual practice, several causes act together to produce not separate effect, but a combined effect. When several causes produce a joint effect, we call it *conjunction of causes*, and the joint effect is called the *intermixture of effects*. The doctrine of conjunction of causes should not be confused with that of plurality of causes. In conjunction of causes, several causes act jointly and produce a joint effect; but in plurality of causes, several causes, each acting separately and independently, can produce the effect, on different occasions, e.g., inflation may be produced by either excess demand, or excess cost of production, or low supply, or excess money circulation. However, the inter-mixture effects may be either homogeneous or heteropathic. In homogeneous intermixture, the joint effect is of the same kind as the separate effects; but in heteropathic intermixture, the joint effect is different from the separate effect.

Cause and Condition

Condition means the necessary factor of a cause. Conditions may be of two types : positive and negative. If the effect is to happen at all, the positive conditions must be present, and the negative condition must be absent. According to Carveth Read, "a positive condition is one that cannot be omitted without frustrating the effect; a negative is one that cannot be introduced without frustrating the effect." According to him, a negative condition means the preventing circumstance itself; but according to Mill, the negative condition means the absence of preventing circumstance. Thus, their views on negative condition are opposite to each other. However, Carveth Read's idea of negative condition does not seem to be correct. Why should the negative condition, which must be absent, for the effect to take place, be regarded as a necessary factor of the cause ?

In popular view, the cause is nothing but one of the conditions. This condition may be the most significant one, first or the last one or even the negative one. Thus, in popular view, the selection of the condition as the cause is somewhat arbitrary. According to the scientific view, the cause is the sum total of the positive and negative conditions. While the cause constitutes the whole, the condition is merely a part of it. But the difficulty is this that all the negative conditions cannot be exhaustively enumerated. In fact, the absence of preventing circumstances may be many and infinite. Even in the enumeration of positive conditions, we do not take into account all the factors. What we actually consider is the proximate and immediate antecedent; the remote antecedent or condition is generally avoided.

Aristotle's View of Cause

1. Aristotle observes that every cause is a mixture of four

factors; and each of these factors is by itself a cause. The four factors or causes are as follows :

The formal cause is related to the change in the form or shape of thing. When an effect is produced, there happens some change in the form of a thing.

2. The material cause is related to the matter or substance of which a thing is made. The nature and extent of the effect depend on the nature of the material. The material on which the effect takes place is to be considered as an element in the causation of changes.

3. The efficient cause of a thing is related to the skill, labour etc., expended to produce the thing. Thus, the skill or efficiency applied to the material to produce a painting is the efficient cause of painting.

4. The final cause of a thing is related to the purpose or objective for which the thing is ultimately done.

Since formal and material causes are related to the constituent elements of a thing itself, they are called intrinsic causes; but efficient and final causes are extrinsic, because they are related only to the external or outside element of a thing.

Popular View of Cause

In popular view, the cause is one of the conditions. There is an element of arbitrariness in the selection of the condition constituting the cause. In popular view, the most striking single condition is selected as the cause. This is arbitrary and unanalytical. According to this view, the antecedent of an effect is regarded as a cause. Although this view is more or less correct, it is not, however, always scientifically true. In the popular view, the cause-effect is explained, more often than not, in terms of personal choice and subjective considerations. A cause is ordinarily understood as the one which produces the effect. This view of cause is anthropomorphical, because it sometimes associates human attributes to non-human things. There is a tendency on the part of human beings to understand the phenomena of Nature in the same way as they understand their own actions. The cause is generally regarded as an agent which acts on something to produce effect. Thus, the popular view of cause is unanalytical, incomplete, arbitrary, personal and unscientific.

Scientific View of Cause

According to the scientific view, the cause is the variable antecedent of effect. The cause is regarded as the antecedent and the effect as the consequent. The cause is the initially responsible condition and the effect is the final result. The cause-effect

relationship represents, according to Mill, uniformity of succession. Every antecedent is not regarded as a cause. Only the invariable, unconditional and immediate antecedent is looked upon as the cause. This notion of cause is conspicuous by its absence in the popular view of cause. In Mill's view, the same cause always gives rise to the same effect.

In scientific explanation, the cause must be regarded, as Bain observes, as the entire aggregate of conditions and circumstances requisite to the effect. The conditions, suppressed by the popular view, are all brought to the surface for a complete statement of cause.

According to Mill, cause is the sum total of conditions, positive and negative taken together. The cause is that group of antecedents which is enough to produce the effect without the presence of any other antecedent. A condition means any necessary factor of a cause. A positive condition is one that cannot be omitted without frustrating the effect; and a negative condition is the absence of a preventing circumstance. A condition is a part of the cause. The sum total of positive and negative conditions will be sufficient for the explanation of the cause. A necessary condition is a factor without which the phenomenon cannot take place; and a sufficient condition is a factor (or a group of factors) which does not require any further condition for the phenomenon to happen. In any explanation of cause, both the necessary and sufficient conditions are to be considered. Thus, the scientific explanation of the cause is thoroughly analytical and its objective is to find out the totality of conditions including the necessary and the sufficient ones. On this count, the popular view is utterly inadequate, because it is neither analytical, nor does it take into account all the necessary and sufficient conditions. Unlike the popular view, the scientific view does neither regard cause as the agent which produces effect, nor consider cause in terms of subjective and anthropomorphic attitude. The scientific view regards cause as a relationship between various facts having the characteristics of invariability, succession and unconditionality. In a scientific system, the explanation of the cause has got to be objective.

Modern Views on Cause

In the modern view, the traditional concept of cause is vague and unscientific. It is, in fact, very difficult to grasp the exact nature of the causal relationship. The cause-effect relationship is explained by human agents through subjective considerations. It is not wholly correct to say that every invariable antecedent is a cause, because it cannot fully establish causal relationship. Mill brought into the analysis, the idea of unconditionality; but relation between invariability and unconditionality is not very precise. In singling out a cause, it is also not physically always possible to pinpoint

all the positive and negative conditions. According to Russell, we cannot find such antecedents which are always invariable.[1] If the consequent is to be properly calculated from so many varying antecedents, the latter becomes so complicated that it is very unlikely that they will again occur.[2] As the science becomes more and more progressive, we go further away from the crude law of uniformity to the wider field where there is greater differentiation of antecedents and consequent, and where the antecedents themselves are perplexing both the number and variety, but they are nonetheless relevant.[3]

The dichotomisation of cause and effect in clear-cut apple-pie order is not possible. The cause should not, and cannot, always be discribed in terms of antecedents. It is impossible to draw a line of demarcation between the ending of a cause and the beginning of an effect. As soon as the cause-events take place, the process of causation begins to appear.

However, according to the view, the causal relationship is neither universal, nor necessary. It is not proper to say that all phenomena of nature are subject to laws. The causal connection is not a necessary connection. The traditional notion of necessity attributed to the cause-effect relation is only formal, and does not and, cannot adequately deal with the universe of matters of facts. Once established, the formal or logical relation cannot be denied. But in the universe of matters of fact, as David Hume puts it, the propositions relating to matters of fact may be denied without any fear of contradiction.

In fact, there is a difference between necessity and uniformity. When we say that relation between X and Y cannot be so, we are expressing necessity; but when we say that the relationship between X and Y is not so, we are revealing uniformity. Uniformity is asserted only for the observed facts. The affirmation of uniformity about unobserved fact is doubtful and probable. Scientific induction which is based on causal connection leading to certain conclusion, loses much of its significance in the analytical framework that examines the meaning of cause. The analysis of Mill's inductive method is not able to bring out perfectly, with the help of proof, the exact cause of a phenomenon. What is done, here, is the elimination of a number of causes from all the possible causes, through the principles of elimination. These principles are derived from Mill's theory of causation; but they are not tenable. Thus Mill's stress on the certainty of scientific knowledge, is, in fact, unscientific.

1. B. Russell, *Analysis of Mind*, p. 96.
2. B. Russell, *Mysticism and Logic*, p. 188.
3. Loc. cit.

Cause and Function

According to Russell, strictly speaking, there is no such thing as cause. Science does not any longer make use of the concept of cause. In fact, in progressive sciences such as gravitational astronomy, the concept, 'cause' never occurs;[4] instead, the idea of functional relationship is used. The notion of 'function' is a mathematical concept. A particular way of describing an equation is to show a functional relationship. If $Y = f\ (x, a)$, it implies that the value of Y depends on the value taken by the variables 'x' and 'a.' Here, 'Y' is dependent variable and 'x' and 'a' are independent variables. The idea of functional dependence is extensively used in both physical and social sciences. In physical sciences, it is possible to determine the values of the variables with exactitude through the help of precise measuring tools. Thus, in physical sciences, the exact relationship between the factors responsible for a phenomenon can be quantitatively determined through the method of functional analysis. When we are able to do this, we can express the scientific laws in terms of causal uniformities; and the causal laws can be replaced, as Stebbing points out, by mathematical functions expressing tendencies.[5]

Russell observes that in science, when we deal with the motions of mutually gravitating bodies, we do not have anything that can be called a cause, and anything that can be called an effect; we have merely a formula. The laws can be expressed in differential equations which hold at every instant for every particle of the system, and which, given the configurations and velocities of instants, render the calculation of configuration at earlier or later instant theoretically possible.[6] In a scientific law, Russell says, what is expressed is not a uniformity of succession or sequence, but a recurring regularity of pattern. A scientific law expresses the sameness of relationship (or better, sameness of differential equations) between the configurations at successive periods. Uniformity of sequence, (i.e., causal uniformity), according to Russell, is replaced by mathematical equation.

Laws in science do not say anything about the order in which the events take place, but they simply speak about the invariable relations existing between the observed variables.

Functional Analysis in Social Sciences

However, functional analysis holds good only in a case where in perfect correlation between various factors. In social sciences, the correlation between various factors is not a perfect correlation; and therefore, it cannot be quantified and expressed mathematically

4. *ibid.*, p. 180.
5. L.S. Stebbing, *A Modern Introduction to Logic*, p. 351.
6. B. Russell, *Mysticism and Logic*, p. 194.

as exactly as that in physical sciences where there is perfect correlation. The elements of human behaviour, as the social sciences study, cannot be given definite functional representation, because, human behaviour is volatile and not amenable to quantitative evaluation. Thus, in such a situation, it is difficult to find out a constant and perfect relation between various factors and elements. In social sciences, we cannot effectively isolate the purpose of detailed study, and, it is not possible to make controlled experiment. The reliability and relevance of data in social sciences, cannot be decided so easily as in physical sciences. The measurement of qualitative data in social sciences is not amenable to the ordinary process of measurement. The traditional method of measurement very often does not apply to social sciences. And without the help of the technique of measurement, the functional analysis cannot be translated into action. The sciences, therefore, take resort to statistical methods to facilitate comparison, to study the relationship between two phenomena and to interpret the complicated data for the purpose of analysis. The best result of a particular cause on a particular phenomenon can be ascertained by using statistical tools like the techniques of variance and co-variance. Statistical methods introduce the techniques of measurement required for functional analysis. They are helpful for evaluating group phenomena, and for handling numerical results in such a way that the significant relationships between properties can be studied. The comparison of a large body of data sometimes helps in finding out a few correlations. But all said and done, it must be admitted that statistical methods cannot be as accurate as the experimental methods.

Plurality of Causes

Plurality of causes states that one effect is connected with many other causes. One phenomenon may be produced in so many ways. Mill observes that "many causes may produce mechanical motion; many causes may produce some kind of sensation; many causes may produce death." But if this be true, it goes against Mill's conception of the nature of cause as an invariable antecedent from which it can be said that same cause produces same effect. But a deep probe into the matter will show that Mill was not wrong. The confusion arises out of insufficient analysis of effect in so many cases where different causes are responsible. Apparently it is true that death is the same whether it is caused by burning, drowning or poisoning. But if a careful analysis is made, it can be noticed that death by drowning is not the same as death by poisoning. In each case the symptoms and signs of death will differ. The effect (death) may appear to be the same to an untrained eye, but factually it is different. In fact, different causes produce different effects. Therefore, plurality of causes for studying the same effect is not valid.

However, "the doctrine of plurality of causes is plausible only if we analyse the causes into a larger number of distinct types than we do the effect." The doctrine neglects the various differentiating factors in so many instances of the same effect.

But when a particular phenomenon or effect has the same feature when it is caused by different factors (i.e., when the effect cannot be differentiated), plurality of causes does not seem to be irrelevant. For example, price-rise may be caused by increase in demand or decrease in supply, but the phenomenon of price-rise caused by demand spurt cannot perhaps be differentiated from the phenomenon of price-rise caused by decrease in supply. There is nothing special, extra or uncommon in the effect between these two situations. The analysis of price-rise cannot by itself reveal any distinct cause, or it may be safely presumed that price-rise has been contributed by any of the causes or several causes. Thus, in social science, the doctrine of plurality of causes does not seem to be invalid.

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MILL'S METHODS OF EXPERIMENTAL ENQUIRY

Experimental Method

It is the objective of every science to find an order among facts. The facts are explained then in a systematic way with the help of two formal assumptions :

(i) The nature is uniform, i.e., given similar conditions, Nature will behave uniformly.

(ii) Phenomena are related in causal conditions; and to find out the causal condition is the primary aim of every science.

Mill thought that discovering causal connections is the fundamental task in induction. Since causal connections hold good invariably and unconditionally, generalisation can be done with confidence. The experimental methods formulated by Mill serve two purposes :

(i) They are methods of discovering causal connections.
(ii) They have demonstrative functions i.e., concerning proof.

Scientific laws can be established to be true. According to Mill, there is "no other uniformity in the events of nature than that which arises from the law of causation." Such uniformities can be conclusively established by these methods. In other words, an inductive argument is vaid, if it conforms to the experimental methods. Five methods of experimental enquiry have been given by Mill.

Method of Agreement

The method of agreement states that if two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree

is the cause (or effect) of the given phenomenon. Suppose that a man suffers from pain in the eyes in the afternoon, every day. In order to find out the cause of the pain, he takes note of the antecedents and finds that while other factors vary from day to day, rambling in the sun is there every day. So he concludes that rambling in the sun is the cause of pain in the eyes. This is called the method of agreement because the basis of the conclusion here is provided by the fact that the instances in which pain occurs agree ony in respect of the cause—rambling in the sun. This method eliminates in a causal situation those factors which cannot actually be the cause.

Criticism

1. It is very difficult to know all the required types of causes for an effect.

2. All the causes may not be known antecedently.

3. For some phenomena, the ca se may not be known.

4. Unless an analysis of an instance into its factors could be found prior to the use of the method, the method becomes useless.

5. The method itself cannot determine whether the analysis is adequate or not.

6. The method cannot function unless assumptions about relevant factors are made.

7. It cannot be said with certainty that a cause is invariably an antecedent of an effect. If something is true of some cases, it does not necessarily follow that it will be true of all cases.

8. The inadequate analysis may lead to wrong conclusion. Sometimes, common factor may be irrelevant.

9. A single cause or factor may be a necessary condition for a phenomenon but may not be a sufficient condition.

Method of Difference

In this method only two instances are required. The two instances resemble each other in every other respect, but differ in the absence or presence of the phenomenon observed. The method states that if an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in common save one, that one occurring only in the former; the circumstance in which alone the two instances differ, is the effect, or the cause, or an indispensable part of the cause, of the phenomenon.

Let us take an example given by Mill. A man in the fullness

of life is shot through the heart; he is wounded and dies. Here, the wound is the only differentiating circumstance between the man alive and the man dead. Hence the death is caused by the wound.

Criticism

1. The instances are to be observed by experiment in this method. But under simple observation, the conditions cannot be controlled and so it cannot be ensured that all other factors are exactly the same.

2. It does not say that particular cause and effect are permanently related.

3. Because of the possibility of inadequate analysis, the possibility of plurality of causes remains present here.

4. The single factor of difference may be a complex factor involving more than one factor and may require further analysis. In such a case, the method is vitiated.

5. The single factor of difference may be only a part of the cause, and not the entire cause. The method fails to distinguish between a condition and a cause.

6. The method may incorporate the fallacy of *post hoc ergo propter hoc*. The fallacy is committed when we say that since an effect is consequent to a cause, the effect is because of the cause. An effect may follow after the introduction of a cause, but still the cause may be irrelevant. If a man sings and another person immediately becomes senseless, this does not justify the conclusion that singing is the cause of senselessness.

Joint Method of Agreement and Difference

The method can be stated like this:

If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common, save the absence of that circumstance; the circumstance in which alone the two sets of instances differ, is the effect or the cause, or an indispensable part of the cause, of the phenomenon.

According to this, we require two sets of instances. We have already seen that rambling in the sun is the cause of pain in the eyes. Suppose, the man further observes that he does not feel pain in the eyes on those days when he does not ramble in the sun. Now, he gets another set of instances in support of his conclusion regarding pain in his eyes. Not only the presence of the antecedent of rambling in the sun is followed by the presence of the consequence of pain in the eyes, but the absence of rambling is also

followed by the absence of pain in the eyes. This is the joint method of agreement or the method of double agreement. The positive instance agrees in respect of the presence of the cause, and the negative instance agrees in respect of absence of the cause.

Criticism

1. Negative instances may not always be relevant. We can have any set of instances as negative instances, even though they may not have any relevance to the phenomenon under investigation.

2. As a method of proof, the method would essentially suffer from the same defects as the method of agreement has.

Method of Concomitant Variation

It states that whatever phenomenon varies in any manner, whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon or is connected with it through some fact of causation. If the antecedent and the consequent vary concomitantly, the antecedent is regarded as the cause and the consequence, the effect. The method is quantitative and needs statistical technique for measurement. In this method, control should be imposed in such a way that other factors remain constant. But in a social science, the fulfilment of this condition is very difficult. The method is suitable for cases involving factors which can vary quantitatively but cannot be excluded completely.

Criticism

1. The method by itself cannot discover causal connections. If cause and effect are given, the magnitude of increase or decrease, however, can be determined.

2. Unless all the instances are properly analysed, the variation of a particular factor cannot be related to effect.

3. Variation will not produce any effect beyond a particular limit.

4. Mere concomitant variations between two phenomena do not establish causal connection between them.

Method of Residues

The statement of this method is: subtract from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents. This method is based on the principle of elimination. It also follows from the principle of

causation that the same cause has the same effect; and same effect has the same cause.

An example will clear the meaning of this method. Suppose a sack full of rice weighs 80 Kg., and the sack itself weighs 2 Kg. (which is already known), then the weight of rice is 78 Kg. The weight, 2 Kg. is the effect of the sack and the weight, 78 Kg., is the effect of the rice. Here, the residue is 78 Kg. Residue implies what remains.

Criticism

1. This method can only work by making use of some causal connections which are already known.

2. It tells us that the residual effect is due to the residual cause. But it cannot tell us what the residual cause could be.

3. Unless the effect of the factor which would be deduced is known, no subtraction from the total effect is possible.

4. When there are various factors about which we do not have any previous knowledge, the method cannot help us.

Conclusion

The canons of experimental enquiry are not capable of demonstrating any causal laws. Experimental enquiry does not lay down any method of proof or discovery. It only describes causal or invariant relation. It only defines the relation of cause and effect. But with the help of these methods, false hypothesis may be eliminated and the field of enquiry may be narrowed down. Even if we cannot eliminate all irrelevant circumstances, they help in establishing the condition on the basis of which we can logically prefer one hypothesis to another, thereby bringing economy into our search for real truth.

Uniformity of Nature

The belief that experimental method can lead to universal and invariable connections, is based on the belief of uniformity of Nature. According to Mill, the process of induction requires the assumption concerning the order of the universe. The assumption is: "What happens once, will, under a sufficient degree of similarity of circumstances, happen again."

The principle states that Nature is uniform. Uniformity means sameness. It presupposes that in spite of changes, Nature remains the same. In nature, changes take place in a uniform way. A particular change takes place under certain specific conditions and certain change takes place under certain conditions. There are

orders in Nature and not chaos. If the conditions remain the same, the same phenomenon will occur; and if same phenomenon occurs, the same conditions must be there.

Uniformity of Nature in some form is necessary for induction. According to Mill, uniformity of Nature appears as the "ultimate major premise of all inductions." If an inductive argument is thrown into a series of syllogisms, one may arrive by more or fewer steps at an ultimate syllogism which will have the principle of uniformity of Nature as its major premise.

Criticism

1. The principle of uniformity of Nature states that "what happens once, will, under a sufficient degree of similarity of circumstances, happen again." This statement is vague. The principle does not tell us what the sufficient degree of similarity is. In order to determine the material circumstances of a phenomenon, we must rely on other criteria, and not on uniformity of Nature.

2. The minor premise of an inductive syllogism being a particular proposition, if we introduce the uniformity of Nature as the major premise, the premises become insufficient to demonstrate a universal conclusion.

3. "The principle does not demonstrate that every pair of phenomena are invariably related. It simply states that some pairs are so connected."[1]

1. Cohen and Nagel, op. cit., pp. 268-269.

12

CONCEPTS

Meaning

A concept is a word or a phrase which symbolises the phenomenon and helps to communicate the finding. For instance, multiplier, marginal efficiency of capital, labour etc., are all concepts.[1] But a concept should not be confused with the phenomenon itself; it only symbolises the phenomenon. Concept is abstracted from the sense perceptions. It has meaning only with reference to a theoretical system. Concepts are logical constructs created from sense impression or complex experiences. Concepts symbolise the empirical relationship and phenomena which are indicated by facts. Thus, concepts and facts are not the same things. A fact is a logical construct of concepts. The process of conceptualisation arises out of abstraction and generalisation of sense impression.

The object of concepts is to study, organise, manipulate and isolate the properties of objects. The act of isolation of properties requires thinking which can proceed by giving names to such properties. Therefore, conceptualisation is essential to the processes of thought and scientific technique, since it renders precise meaning for communication and brings about economy in the use of language. Concepts are not only basic to scientific method, but they are the foundation of all human communication and thought.[2]

In a science, concepts must be communicable in a special sense. They must be constructed in such a way that their components are known. Clarification of the elements of such a construct is the main function of definition, which is considered basic to the general problem of conceptualisation. The process of communication becomes difficult between individuals who do not share the

1. M.H. Gopal, *An Introduction to Research Procedure in Social Sciences*, Asia Publishing House, p. 109.
2. Goode and Hatt, *Methods in Social Research*, McGraw-Hill, p. 43.

conceptual system. Concepts develop from a shared experience. The development of a conceptual system is very much like the development of a new language.

Categories

On the basis of origin, concepts may be classified into two categories: (i) postulational concepts and (ii) intuitive concepts. The first type has its meaning only with reference to some deductively postulated theory. Its meaning will be different when it will be used in some other context or theories. For instance, the concept, "elasticity", has one meaning in economics and another meaning in physics. As Prof. Northrop observes, no concept, carries its meaning intact from person to person and from theory to theory. Each concept is relative to the postulate of the system of the scientist or philosopher who makes use of it. Intuitive concept has a particular meaning. The meaning is never changed by the people who use it. This type of concept denotes something, which is immediately apprehended, e.g., 'red' as colour. Its meaning is abstracted from a wider and empirical context. Intuitive concepts are divided into two forms in theoretical logic—those by sensation and those by introspection. Similarly, postulational concepts are divided into those by imagination and those by intellection. However, for the matter of social science research, such classification and sub-classification do not convey any special significance.

Features

In every field of study, concepts are used to convey special meaning. The concept, in each area of study, is like a code language which is not easily understood by others belonging to different disciplines. Thus, the concepts of physics are not easily understood by the sociologists or economists. "Each concept, in short communicates to the specialist a vast amount of experience, abstracted and clarified for those who understand the term." Therefore, the basic equipment of any student is the knowledge of scientific vocabulary adequate to understand the conceptual development of his area of interest. Concepts should be precise, comprehensive and clear. There should be no misunderstanding about them. Sometimes common words and phrases are given special connotation to make them concepts, e.g., multiplier, indifference curves, games theory etc. All these are common words but they have got altogether different conceptual meanings.

A term may have different connotations in different sciences. A term may refer to different phenomena. For instance, the term "function" has got different meanings in different fields. In social anthropology, it denotes the contribution which a given belief or practice makes towards the continued existence of the society. In mathematics, we express one phenomenon (say, demand) as a

function of another phenomenon (say, price). In socio-economic analysis, function refers to occupational phenomena. Therefore, one has to be cautious in using such a concept. Concepts must not have multiple meaning. It is possible that different terms may refer to the same phenomenon; and there may be the danger of overlapping of meaning, for instance, marginal utility and final utility. A term may have no immediate empirical reference at all. This makes concepts less well-understood. These concepts have as referents the logical relationship between other concepts. For instance, 'social structure' being the structure of a group, is not subject to physical measurement. Such a concept has a very complex series of referents. However, ultimately there is an empirical referent; but it is not immediate.

How to Use Concepts

In research, the proper concept has to be carefully chosen and its usage should be explained thoroughly. A proper definition of the meaning of the concept is something which cannot be avoided. The meaning of the concept does not remain fixed all the time. The meaning of the concept is modified with the accumulation of knowledge. In course of time, some concepts may become outmoded and irrelevant, and therefore, they are discarded. As the focus of a science changes, attention may be concentrated on different aspects of the same concept in such a way that its meaning is ultimately changed. Concepts grow with the increasing experience of the scientists. Thus, instead of using 'status' alone, we may use 'status', 'rank', 'position' etc.

Conceptual difficulties and ambiguities may be reduced by joint discussion and research. As science progresses, conceptual difficulties are cleared away. Every researcher must learn the conceptual tools of his field. When ambiguity arises, he must become aware of the ambiguity. There must be some process of clarification of thinking about the concepts used in research. This may be called the process of re-conceptualisation. It requires a great deal of patience and care for such refinement, but the trouble is paying, as it brings to the surface many of the complex problems. Re-conceptualisation assures more fruitful hypothesis. Its main aim is to integrate different levels of observation and theory. It should not be considered as a method of manipulation of concepts, but as an attempt to isolate and collate behaviour in many fields. Exhibitionism on the part of the new researcher through manipulation of concepts, and giving new names to old concepts, is foolish, and should be avoided by scientists who are after truth and not after words.

For avoiding this superficiality, one must have full command over concepts. Their connotation, significance and usage must be understood precisely and clearly. Sometimes concepts may be

vague and ambiguous, as the "socialistic pattern of society" in India. Such concepts should be recognised, if they are to be scientific, and meaningfully applied. This will save the investigator from many a difficulty.

The use of over generalised concepts, like 'function', 'nationalisation', 'modern society' etc., should be avoided. If possible, the general concepts should be translated into concrete concepts with reference to the context. A little reflection and patient search will help in getting concrete concepts. The use of concepts in one context, developed altogether in different context, involves considerable risk, particularly when the concepts become the basis for policy prescriptions. For instance, the classical concept of full employment cannot be used in the same sense as the modern concept of full employment. Deficit financing in all the countries does not convey the same meaning. Similarly, underemployment in one analysis may be in terms of time, but in another, it may be with reference to income. Many of the concepts of advanced economics do not work, for explaining the situations of underdeveloped countries. But still, concepts are borrowed. This may be partly due to incapability or unwillingness to coin new concepts, and partly due to the temptation of using known and high-sounding traditional concepts. In order to develop a working definition, considerable research must be done. Operational definition may be more complex and less fruitful than a traditional definition. Operational definition should not be taken as a fashion. We have got to make a conscious choice between precision and significance. However, as research develops in precision and scope, one can find ways to achieve both.

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MEASUREMENT

Purpose of Measurement

In our daily life, we only distinguish the character and qualities of things, and on the basis of this, we reject or choose certain things. In day-to-day affairs, it is necessary to make judgement upon qualities which cannot ordinarily be differentiated from one another. Propositions affirming qualitative differences are the first fruits of enquiring in sciences.[1] But it is not enough to know only the qualitative differences in daily life or in sciences. It is more necessary to know the magnitude of such differences precisely. This is required for exactitude and accuracy of statements and for discovering comprehensive principles on the basis of which the subject matter can be known to be systematically related. If we can know the degrees of qualitative differences, we can not only rule out errors but can take up adequate measures to control the indicated changes as well if required. In sciences, the accurate measurement of phenomena can give us great practical control over the studied subject, and can make possible the formulation of principles or laws which can make confirmation or refutation unambiguous and clear.

Quantitative distinctions are substituted for qualitative ones, for theoretical and practical reasons. But many people, without knowing the meaning and justification, often use quantitative distinction. For indicating the qualitative differences, the use of numbers requires a careful examination, if we are to avoid absurdity and errors. In order to deal with simple matters in our daily life and in sciences, we need not resort to complicated methods of registering differences. "Measurement, calculation, and the often difficult deduction of consequences from premises, would not require the elaborate techniques which they, in fact, do require." But sometimes a more intricate technique than a bare common-sense method is required for formulating collecting and estimating

1. Cohen and Nagel, op. cit., p. 289.

evidence. Investigations cannot, perhaps, be properly and fruitfully carried on without the introduction of quantitative methods. Scientific method, therefore, must study the foundations of applied mathematics.

Formal Conditions of Measurement

For measuring the qualitative differences, the minimum requirement for employing numbers may be stated in the following first two conditions:

1. In a set of n bodies given, $A_1, A_2, \ldots A_n$, one must, with reference to a certain quality, be able to arrange them in such a way that between any two bodies one and only one of the following relations holds:

(i) $A_1 > A_2$ (ii) $A_1 < A_2$ (iii) $A_1 = A_2$. On the basis of the signs $>$ or $<$, the qualitative differences in bodies can be studied. The relation $>$ must be asymmetrical.

2. If $A_1 > A_2$ and $A_2 > A_3$, then $A_1 > A_3$. This is known as transitivity condition.

The above two conditions are sufficient for the measurement of intensive qualities, e.g., density, temperature etc. For the measurement of extensive qualities, they are necessary but not sufficient. Measurement of extensive qualities requires some physical process of addition which should have the following formal properties.

3. If $A_1 + A_2 = A_3$, then $A_2 + A_1 = A_3$.

4. If $X = Y$, then $X + Z > Y$ (where the value of Z is not zero or negative).

5. If $A = X$ and $B = Y$, then $A + B = X + Y$

6. $(A+B)+C = A+(B+C)$

If these conditions are satisfied, measurement becomes possible. With the fulfilment of first two conditions, it cannot be said that all the six conditions hold. If the I.Q. of a man is twice that of another, we only mean that the first man is higher than the other on a specific scale of preference. It is absurd to say that the first has twice the intelligence or training, because operation for adding intelligence or training has been found out which is consistent with the last four essential conditions.

Nature of Counting

Counting is a method of judgement of enumeration. In actual counting, classification and analysis are required, and enumeration of instances is helpful for induction. In order to more exactly enumerate the parts of which a whole is composed, we

require weighing or measuring. There is no essential difference between weighing and measuring. In measurement, we make comparison. In measurement, we express the relation of the parts with some common standard or unit. Through measurement, the things are reduced to common terms. It is really the business of the physio-mathematical sciences. Counting and measuring help us in achieving the exact body of knowledge which we call science.

Counting gives us the exact knowledge and tries to avoid the vague ideas. When we suspect significant connections between groups counted, counting is taken up. Counting makes our ideas precise and it helps us in distinguishing various features of different groups. However, only a discrete group can be counted. The number of individuals in a group represents an invariant property of the group. From this arises the great importance of counting as a method of clarifying our ideas. Applied arithmetic is partly a collection of rules through which the invariant property can be easily discovered. Counting must be objective.

It is very difficult to count unless we know that what it is that we are counting. Where the difference between the groups is not distinct, the interpretation of the number obtained by counting is uncertain. Thus it is not easy to draw the line of demarcation between skilled and unskilled workers. In a social science research, the information which we get from the questionnaires is not always reliable, because the questions themselves may be ambiguous or not very clear or distinct. The answers may also be affected by ignorance, dishonesty and vanity. However, if the groups are very large in numbers or difficult to examine exhaustively, then enumeration is not undertaken. In such cases, sampling method is practised.

Measurement of Qualitative Data

In social sciences, we face problems which are subjective and qualitative, e.g., skills, values, attitudes, utility, etc. Qualitative data cannot be quantitatively or objectively measured. But qualitative data cease to be of much scientific value unless such data are quantified.

Prof. Menegazzi[2] pleads for greater attention to the qualitative aspect of social life—to the synthetic or aggregative approach to the problems. It is to some extent possible to measure the intensive and extensive qualities. The qualitative data can be translated more or less satisfactorily to quantitative terms. The technique of such translation has several steps: description, categorisation, and determination of quantitative incidence and inter-

2. G. Menegazzi, *Method and Foundations of Social Science*, 1957.

relations.[3] These steps are generally known as "content analysis".

Measurement of Intensive Qualities

There are some things e.g., hardness, density, intelligence, etc., which have non-additive qualities. These qualities are called intensive qualities. These qualities can be measured only in the sense that the different degrees of the quality may be arranged in a series. In this case, the questions regarding "how much" or "how many times", are meaningless: the qualities cannot be added.

Characters of things cannot always be distinguished, because they form a continuous series with one another. Sometimes it is sufficient to know that one piece of wood is harder than another. But if we want to know how hard one piece of wood is as compared to another piece, then we require a very certain and uniform criterion. The varying degrees of quality can be indicated by assigning different numbers—e.g., 1, Q. of A is 50, and 1 Q of B is 100 etc. But in this way we cannot get the correct measurement. It should not be considered that measurement requires nothing more than the assigning of numbers. But by assigning numbers, we can only indicate the degrees of intensity i.e., which one is higher and which one is lower. In the above example, it should not be interpreted that B is twice as intelligent as A. Such a precise measurement is not possible in the case of an intensive quality by assigning numbers. All qualities cannot be measured in the same sense.

Numbers have three uses to perform:

(i) As identification marks or tags.

(ii) As signs to indicate the position of the degree of quality in a series of degrees.

(iii) As signs indicating quantitative relations between different qualities.

(i) Sometimes numbers can be used to indicate names or identity, e.g., convict No. 100, convict No. 200, etc. Numbers are more convenient than verbal names for various reasons. But the assigning of the numbers does not indicate any relation between the objects numbered corresponding to the numerical relation between the assigned numbers. Thus, convict No. 100 is not twice as criminal as convict No. 50.

(ii) "A scientifically more important use of numbers is when the order of numerical magnitude is the same as the order of the

3. M.H. Gopal, op. cit., pp. 204 ff.

position of the character studied, in a scale or ladder of qualities."[4] Intensive quality can be arranged as a relational property. For example, if, by experiment, we can show that diamond is harder than glass, and glass is harder than pine-wood, then we can show that diamond is harder than pine-wood. Here, relational property is transitive. The relational property is said to be asymmetrical, if A_1 is harder than A_2, but A_2 is not harder than A_1. By arranging the bodies in a linear series, according to quality, we can get a scale or ladder of this quality.

If the relation of magnitude of numbers is asymmetrical and transitive, we can arrange different unequally hard bodies, e.g., A_1, A_2. . . . . . . .A_{100} (A_1 is the hardest and A_{100} is the softest body), and we may assign numbers to them to indicate their relative hardness in such a fashion that the order of numerical magnitude is the same as the order of relative degrees of hardness. We may assign the numbers 1 to A_1, 2 to A_2. . . . . .and so on; or 5 to A_1, 10 to A_2 and so on. However, we should not say that A_2 is twice as soft as A_1. Such an interpretation is meaningless, because we have only prepared a scale, but we have not exactly measured the qualities. Since, quality cannot be added, it is difficult to make quantitative comparison of qualities. The scale cannot speak anything about the quantitative aspect.

Measurement of Extensive Qualities

There are some things the qualities or properties of which are additive, e.g., areas, angles, electric current, lengths etc. The properties which are additive are called extensive properties. (iii) Numbers can be employed to measure the quantitative relations. In order to measure the weight of something, we are to construct a scale or ladder of weights. By the measurement of weight with the help of a scale, we can know experimentally whether A is heavier than B or not. The relation, "heavier than" can be, thus, experimentally known to be transitive and asymmetrical. When we measure with the help of a scale, one of the three possibilities is apparent:

(i) A is heavier than B

(ii) A is equal to B

(iii) B is heavier than A.

Since weight can be added, we can say, for instance, that A is twice B in weight, or A is equal to B in weight, and so on. Now, suppose the weight of A is regarded as the unit or I, and that we

4. Cohen and Nagel, op. cit., p. 295.

assign weights to other things by this process so that A_2 is equal to 2, A_3 is equal to 3, and so on. Then, will $A_1+A_2=A_3$? We cannot say anything about it certainly, unless we make the experiment. In pure arithmetic this is true, but in physical operation of addition of weights, unless experiment is made, we cannot say with certainty whether such operation will conform to the properties of pure arithmetical addition or not. The formal properties of arithmetical addition will be found to be true only in some cases of physical operation of addition of weight, but not in all cases. However, the method of measurement of weight can be extended to measure other properties. Cohen and Nagel call such measurement fundamental.

Steps in Measurement through Content Analysis

1. It is necessary to know the characteristics of the content i.e., description, categorization, inter-relations etc. The substantive nature of the content must be known and the data should be compared at different points of time.

2. The concepts should be precisely defined and the data should be specified.

3. Content analysis must present the picture, intentions, psychological state and cultural pattern of the communicator.

Categorization : The attributes must be categorised. Categorisation should be based on explicit agreement. The operational definition of every category is necessary. Categorization is required for the quantification of the attributes. The categories must form a continuum, i.e., an identifiable and logically related series. Every group should be distinct. The coding of qualitative materials can be done by noting the presence or the absence of an attribute. This is known as the dichotomy approach. The degree of intensity can be recorded by ranking the material i.e., by means of the preparation of a scale of intensity. The formation of a graduated series, can be done if the data are scalable. Another method is the introduction of equal intervals in the scheme of categories i.e., variables. But this method is not possible in all cases. This can be utilised where money unit, time etc., are involved.

Validity and Reliability : A scale is reliable if it gives the same result consistently when applied to the same sample.

In scaling technique, different methods are applied for testing reliability :

(1) The scale may be applied to the same population twice over.

(2) The scale may be constructed in two forms and be

applied to the same sample. "The greater the correspondence between the two, the greater is the reliability."

(3) The scale itself may be divided into random halves. The degree of correlation between the two halves, would mean the degree of reliability.

Validity implies that the scale actually should measure what it claims to measure. If the items are carefully selected, and the continuum is set up, validity follows logically. Validity may be tested by the help of the opinions of experts. Independent alternative criteria may be taken up to test the validity of a particular method of measurement. For instance, under-employment is measured in terms of time, but it can also be measured in terms of income. The two methods may reinforce each other. In order to study a phenomenon, it is best to utilize all the possible methods. In a scale, the qualitative items may not have equal importance. Thus, it is necessary to give suitable weightage to the more important items, as is done in the preparation of index numbers. This will increase the validity of the scale. However, in social qualitative measurement, absolute reliability and perfect validity should not be expected.

Some Requirements for Measurement

For effective measurement, the unit of enumeration must be determined. Either a single respondent, or a part of the content may be taken as the unit of enumeration.

It is better to have the same system of categories, same units of enumeration and the same operational definitions. In order to know quantitatively the degree of deviation, it is very necessary to have certain norms.

The tools of measurement of qualitative data can be applied if the following steps are taken :

1. The data should be specified, and a matrix should be developed with an attitude scale and scoring devices.

2. The coded data should be properly tabulated.

3. A list of variables in terms of which the content is to be coded, should be prepared.

4. The categories of each variable should be filled in. The categories should not be either too broad or too narrow.

5. Proper definitions and procedures should be used.

6. The outline of the analysis may be prepared, in the fashion of a pilot survey.

The success of measurement depends on the theoretical

procedure, and on the coders. The method of measurement should be, as far as possible, accurate, and, the coder must be neutral, alert, trained and painstaking.

Numerical Laws

Numerical laws play an important role in scientific methodology. Such laws connect physical properties, and can measure many intensive properties e.g., density and temperature. The aim of science is not only to establish such laws singly, but also to find out how numerical laws are themselves connected with one another. However, unless some properties were measurable by a fundamental process, numerical laws would be difficult to find out, and the derivated measurement of intensive qualities cannot be undertaken. Since fundamental measurements of social phenomena are difficult, and since there are only few numerical laws connecting intensive and extensive properties, social sciences are faced with difficulties in measuring intensive qualities. General invariant laws can be discovered only when the different properties of bodies are distinguished through successful techniques of measurement.

14

STATISTICAL METHODS

Need for Statistical Methods

Statistical methods are a mechanical process specially designed to facilitate the condensation and analysis of the large body of quantitative data. The aim of statistical method is to facilitate comparison, study relationships between the two phenomena and to interpret the complicated data for the purpose of analysis. Many a time, comparisons have to be made between the changes and results which are due to changes in time, frequency of occurrence, and many other factors. Statistical methods are used for such comparisons among past, present and future estimates. Such methods, e.g., extrapolation, can be applied for the purpose of making future forecast about the trends of, say, demand and supply of a particular commodity. The best result from a particular cause on a particular phenomenon can be ascertained by using statistical tools like the techniques of variance and co-variance.

Statistical methods are applicable to a subject where enquiry and investigation are essential to arrive at the truth. Scientifically analysed data are the foundation of sound policy formulation. The use of statistical methods can be helpful in enlarging human experience and knowledge. They are techniques required for handling the multitudes of numerical results in such a way that the significant relationships between properties can be studied. The method of concomitant variation, when applied to varied instances, requires statistical techniques. These methods are not merely important for collection of data, but also for compressing and summarising as well. Certain things cannot be predicted with accuracy, but still, the comparison of large collections of data sometimes helps in finding out a few correlations. "The methods used to evaluate group phenomena by an analysis of data supplied by enumeration and measurement comprise the science of statistics."

Numerical data can be simplified by classification, the nature

of which depends upon the purpose of enquiry. Frequency table is helpful in giving an overview of the materials. The distribution of frequency intervals is expressed with the help of two numbers : (i) statistical averages and (ii) dispersion or deviation number. The former describes the position of distribution, the value around which the items centre. The latter gives the extent of variations of items with reference to an average.

Be that as it may, the statistical methods are applied to simplify a huge body of data into a simple statement of facts and tendency. But the fact remains that statistical methods cannot be as accurate as experimental methods.

Steps in Statistical Methods

Statistical method has been defined "as the collection, presentation, analysis, and interpretation of numerical data." Thus, statistical method involves four steps :

Collection of Material : In order to have a reasonable standard of accuracy, data must be collected in a systematic manner. The data should be reliable, purposeful and adequate. The data are observed, counted and analysed in a systematic manner with reference to the problem. The facts are to be collected from a large area. The data are collected by four methods : (i) Library method, (ii) Experimental method, (iii) Observation method, and (iv) Questionnaire method. However, it should be noted that only the relevant data should be collected carefully.

Presentation of Data : After collection the data should be suitably classified. Classification is the process of arranging things with some purpose—with respect to some variables or attributes. The classified data should then be presented in a clear manner either with the help of diagrams or with the help of graphs.

Analysis of Data : The classified data then should be properly analysed with the help of statistical tools, like average, dispersion, correlation, association etc. The analysis involves mechanical processes, and it requires the knowledge of the application of statistical techniques. In analysis, the significant facts are abstracted from the huge body of data.

Interpretation of Data : It involves the study of those techniques by which inference or conclusion can be drawn correctly. We must be able to interpret what the data tell us. It should be noted that the interpretation must be with reference to the studied data. If the data are not sufficient, the inference becomes only probable.

Simple Enumeration

Simple enumeration consists in arguing that what is true of several instances of a class, is true of all the instances of class. For example, if we see that some roses have thorns, we may conclude

that all roses have thorns. In this way, some generalisations can be made. The generalisation established by simple enumeration has the following features :

1. Generalisation is established on the basis of the observation of some instances and not all the instances of a class.

2. The generalisations of simple enumeration are always probable and not certain.

3. Generalisation is established on the basis of uniform or uncontradicted experience.

4. The generalisations have different probability values.

5. Generalisations are not based upon the scientific analysis of properties of instances observed.

Simple enumeration plays an important role in scientific investigation. On the basis of the generalisations, we can make scientific hypothesis. Sometimes, simple enumeration suggests causal relation. Simple enumeration is very useful at the initial stage of scientific investigation. It suggests a kind of uniformity in the observed instances. This uniformity makes us think as to why certain events occur and why certain things have particular properties. Scientific investigation starts from simple enumeration. Therefore, one can say that simple enumeration is the starting point of scientific discovery.

Application of Statistical Method

Statistical approach is a quantitative micro-approach. It is thus inadequate for social analysis, because the social problems require a macro-approach—a qualitative analysis.

Statistics studies the individual traits in a large number of separate units and takes a horizontal view of society over a large body of data. The classes of facts to which statistics is applied have two characteristics :

(1) The classes of facts are very complex. The data are affected by a multiplicity of causes.

(2) The facts are of such a nature that the laws underlying the event or phenomenon to be investigated, cannot be directly made applicable.

Thus, (i) statistical method is applied to those facts which cannot be counted or measured. (ii) In order to determine the death-rate of a particular society, we cannot apply any law or principle. So, one has to count physically the actual number of deaths. Experiment in such a case is impossible. However, where general laws can be applied or experimentation can be made applicable, we need not use statistical method. In Astronomy, laws are

discovered by which the eclipses of the sun and the moon can be known even for a very long period. Thus, in this case, it is not necessary to apply the statistical method. But there is no law to know meteorological changes. Hence, statistics can be applied to know the meteorological changes, like changes in weather etc.

The statistician selects certain specific factors involved in social institutions and manipulates them so as to discover the involved relations. Statistical technique is concerned with the nature of the common denominators and can only correlate a few factors. Any case study, however, has to turn to statistics if its data are to reveal frequencies, types, trends, uniformities and so on. The case study technique and the statistical method are complementary to each other.

Advantages and Uses of Statistics

1. Statistics makes a comparison between present and past data possible.
2. It is also useful for making projection and extrapolation.
3. Certain important correlations and association of attributes can be found with the help of statistics.
4. It explains facts by revealing quantitative uniformities and relations between facts.
5. It enables us to form a probable inference by calculation of chances and estimation of probabilities.
6. It describes facts precisely through convenient presentation of facts and data.
7. It leads to economy and high degree of flexibility.
8. It is useful for the study of management, economics etc., and it is very helpful to bankers, state planners, speculators, researchers etc.
9. Its approach is quantitative and hence, definite and reliable.
10. It enables us to give a horizonal view of society across the vast area of data.

Distrust and Misuse of Statistics

Statistical methods are only tools. As such, they may be very often misused. It is said that figures cannot prove anything. Some people regard statistics as the worst type of lies. There are three types of lies—lies, damn lies and statistics. Statistics are the lies of the first order. An ounce of truth can produce tons of statistics. Mere quantitative result, or huge body of data, without any definite

purpose, can never help to explain anything. The misuse of statistics will arise from the following situations :

(1) Analysis without any definite purpose.

(2) Carelessness in the collection and interpretation of data.

(3) For misleading others, and for self-interest, some unscrupulous persons may cook up data.

(4) Pressure on statisticians, and bias and prejudice of the statisticians.

(5) Wrong definitions, inadequate data, wrong method and inappropriate comparison etc.

As a principle, statistical method cannot prove anything; but it can be made to prove anything. The fault lies not with statistics but with the person who is using statistics. Figures cannot tell lies, they are innocent. The tools must be used correctly without any bias. The science of statistics is a most useful servant; but it is only of great value to those who understand its proper use.

Dangers and Fallacies in the Use of Statistics

Statistical methods, though very useful can lead to the following dangers and fallacies:

1. Statistical numbers supply information about the characteristics of the group, but they do not speak anything about any individual item. From the knowledge that male-female ratio is 1:2, one cannot say anything about the number of males or females in a particular family.

2. Statistical averages cannot represent an invariable relation in a group. The number of divorces may be 500 per year over a long period of years; but it does not follow that this number of divorce must occur annually. The variation may be caused due to a number of factors.

3. Co-efficients of correlation are not free from defects. Pearson's definition states that any two groups may be investigated for knowing the extent of correlation. But the groups may be quite independent of each other. The spread of cancer in England was shown to be correlated highly with the increased import of apples. The correlations of this nature are generally absurd, and do not show any causal significance. It is really difficult to interpret a coefficient, because its value may be consistent with a number of hypotheses. Therefore, invariable connection cannot be sufficiently proved by a high co-efficient of correlation. Increased number of arrests do not lead to the conclusion of increased number of crimes; the former may be due to severity in law enforcement.

4. Frequent associations between two events often lead us to the erroneous belief that they are invariably connected. We may find that in 9 cases out of 10, rich people are bald-headed. But from this we should not infer validly that riches and baldness are connected in some special way. People other than bald-headed ones may also be rich.

5. High coefficient of correlation can be found by mixing two sets of data in which generally no correlation is to be seen. If in one community the coefficient correlation between the ages of husband and wife is 0.856, it does not follow that the same will be true of another larger community. Co-efficient is subject to variations in sampling. A relatively high correlation sometimes may be only casual.

6. When sampling is not fair, adequate or representative, it may lead to dangerous fallacies. During the Spanish-American war, the death rate in USA Navy was 9 persons per thousand, and for the same period death rate in New York city was 16 persons per thousand. This does not lead to the valid conclusion that the Navy was a safer place than New York city. Because the error was that in calculating the death rate of New York, the mortality of infant, old and diseased people was included, whereas in the case of Navy this was not done.

7. Sometimes absolute numbers are used in comparing two groups, and percentages are neglected. This becomes a source of fallacy. If percentages are calculated, perhaps one would find a different story, in so many cases, than what the numbers say. If we compare the marks obtained by two students, A and B, we may have a hurried impression that A, who has got 500 marks, is a better student than B, who has obtained 480 marks (out of full-marks 1000 and 800 respectively). But the percentage calculation which is more sensible here, will tell us that B is a better student than A.

8. Fallacy may arise when comparison is made on the basis of units or classification without regard to value or meaning of the units. Money income of a man might have increased this year, compared to the previous year. But this does not justify the conclusion that he is better off, because the value of money might have gone down to a greater extent than the increase in income, as is evident in some of the developing countries.

9. Another important source of error is neglecting to differentiate changes in the definition of subjects or in the method of collection of data. Such changes may occur from census to census. As Falker observes, it is possible to lower infant mortality without saving a single infant life, by improving the birth-registration.

10. Different results may be obtained for a social phenomenon by applying different norms or units to make comparisons. There are different methods for measuring a certain feature. For

instance, efficiency can be measured by productivity, or profit or output or cost. All these norms will not give the same result. The acceptance of a particular norm is neither fool-proof nor non-controversial.

11. The appearance of precision introduced by statistical methods is misleading, if one thinks that the correctness of the data is enhanced by them. Where inconsistency of data is not apparent, more thorough methods should be used for testing consistency.

However, we may conclude with the words of Marshall who says, "statistical arguments are often misleading at first but free discussion clears away statistical fallacies."

15

PROBABILITY AND GENERALISATION

Meaning

In scientific method, probability means anything between certainty and impossibility. But in popular meaning, probability is something which is more likely to happen than not. In the scientific sense, probability is a matter of degree, ranging between two extremes—impossibility and certainty. Theoretically, it is a measure of likelihood of occurrence of a chance event. This theory is based on the belief that the same set of causes is accompanied by the same effect. Thus, the question of belief is always related to the concept of probability. Probability is equal to the number of ways favourable to the event, divided by the total number of ways, both favourable and unfavourable. Probability is sometimes represented as a fraction, and sometimes it is represented as a proportion. The question of elimination of chance is bound up with the question of probability. When we cannot certainly predict the occurrence of an event, due to our imperfect knowledge, we have got to estimate its probability.

Nature and Grounds of Probability

According to some logicians, the ground of probability is purely subjective, i.e., it depends on our personal belief. But according to some other logicians, the ground of probability is objective, i.e., probability depends on experience. However, probability is neither simply subjective nor simply objective. It is both subjective and objective.

"Probability refers to the likelihood that a given statement is a true statement. This conception of probability relates to the amount of knowledge lying behind a statement whose probable truth is being evaluated."[1] "Probability is a type of inference which aims at providing a mathematical calculation of the likelihood that every possible alternative should lead to certain event." In other

1. Goode and Hatt, *Methods in Social Research*, p. 210.

words, probability is concerned with the calculation of chances of every possible alternative to give rise to an event. Probability is an attempt to provide the determination of an event quantitatively by eliminating chances. Probability attempts to provide a rational explanation through the introduction of mathematical calculations by eliminating chance, which has no place in logic. But probability calculation is never certain; and it only gives the probable result.

The numerical value of probability lies between zero and one. Probability is a positive number but not greater than unity. If an event is certain to happen, its probability is one; and if it is certain not to happen its probability is zero. One can get the idea about probability only when certain conditions are fulfilled. These are:

(i) the events must be mutually exclusive;

(ii) the events must be exhaustive;

(iii) the events must be definite;

(iv) the events must be equally likely.

The probability of an event can be found out only after conducting a large number of similar experiments. But if we want to find out the probability of an event prior to conducting experiments, we use the principle of indifference or the principle of insufficient reason. This principle proposes that whenever there is no basis for preferring one event over others, all events should be treated as equally likely. All events are reduced to equally likely simple events and then the ratio of favourable events to total number of equally likely events, is taken. This is known as *a priori* theory of probability. Thus, the probability of obtaining 9 in rolling dice is zero and of obtaining less than 9 is one.

The probability of an event changes as conditions regarding its sample space change. It is meaningful to talk about the probability of an event only if we specify a sample space in which the event is represented by either a simple or a compound event.

Probability and Inductive Generalisation

Induction and probability are mutually related. It is believed that probabilities are based on induction. However, Jevons observed that induction is based on probabilities. The causal connection in induction is never certain. Our knowledge is imperfect, and there is the possibility that certain causes are existing although we do not know them. These causes may produce unexpected effects. The conclusion in an induction is only probable. However, the induction forms the objective ground of probability, because the material for our probable conclusion are derived from our experience. A probable argument is that type of argument where

premises only justify probable conclusion. The conclusions of simple induction, analogy, etc., are only probable and not certain. In simple enumeration no causal connection is known to exist definitely. Similarly, in analogy the argument is based on imperfect resemblance. Since in induction all the possible and relevant cases cannot be observed and studied, induction yields only probable generalisation. When we say that the generalisation is valid in many cases or in most of the cases, we only speak about approximate generalisation. The degree of probability of an approximate generalisation depends on the proportion between the agreeing instances and non-agreeing instances. However, in our daily life, we use approximate generalisation or probabilities. Hence, Bishop Butler has rightly pointed out that probability is the very guide of life. In science, the value of approximate generalisation is not very significant. Approximate generalisations may be of two types, e.g., those that are definitely known to be probable, and those which are probable at the present state of our knowledge. The conclusions of simple induction may be taken as the basis of scientific induction. Analogy and approximate generalisations may lead to certainty through the discovery of definite causal connection, and of more relevant facts and figures. When the premise cannot suggest a universal conclusion, the argument becomes necessarily probable. In induction the inferences that are drawn from approximate generalisations are only probable, and not certain.

Interpretations of Probability[2]

The origin of probability has been given different interpretations. Two such important interpretations are discussed below :

Probability as a Measure of Belief

According to De Morgan, Laplace and Keynes, probability is identified with the strength of belief. To De Morgan, probability is the state of the mind with reference to an assertion, an event or a matter on which complete knowledge does not exist. When we say that "it is more probable than improbable", we, in fact, believe that it will happen more than we believe that it will not happen. When people do not have omniscience or sufficient knowledge, we have got to rely on probability. If an event is sure to happen, its probability is one; and if it is certain not to happen, its probability is zero. But when our belief is intermediate between certainty of its occurrence and certainty of its non-occurrence, the probability is between 1 and 0. When our ignorance is equally distributed over several alternatives, the calculus of probability may be applied. However, when there is no basis for preferring one event over

2. Cohen and Nagel, *An Introduction to Logic and Scientific Method*, pp. 164-72.

others all events should be treated as equally likely. This principle is called the principle of indifference, or of insufficient reason. If there is perfect indecision, i.e., belief inclining neither way, we can say that the two alternatives are equally probable. When we are completely ignorant about two alternatives, the probability of the occurrence of one of them is 1/2. When one says that the probability of getting a head in tossing a coin is 1/2, one has reached this conclusion by reasoning or deductive method. This is the *a priori* theory of probability. Hence, no trial is required before the assignment of probability. The result, here, does not require that a coin be actually tossed, or even be at hand. What is required is the knowledge of the antecedent conditions. As per the *a priori* view, all events are reduced to equally likely simple events, and then the number of ways in which an event can occur, is divided by the total number of equally likely events, and the ratio that is obtained becomes immensely helpful. But the interpretation of probability as a measure of belief has several limitations, such as:

(i) Belief cannot be satisfactorily and objectively measured.

(ii) Belief does not uniformly correspond with the state of facts.

(iii) Beliefs about the same events may vary to a great extent.

(iv) Mere belief is not enough. It must be based on facts and experience about facts.

(v) In order to be meaningful, beliefs have got to be combined. But, in fact, belief cannot be measured.

(vi) Unless the range of its application is limited, the psychological theory of probability is prone to lead to absurd results.

These limitations have led to the interpretation of probability as the relative frequency.

Probability as Relative Frequency

According to this interpretation, probability is not based on subjective feelings, but is grounded in the nature of classes of events. Here the probability of a unique event is meaningless. This theory is capable of explaining probability judgements that arise out of statistical investigations. In this theory, probability is regarded as the relative concept. The relative frequency theory of probability is an alternative to the *a priori* theory. This frequency theory states that "if a large number of trials be performed under the same conditions, and if the limit of the ratio of number of happenings of an event to the total number of trials is unique and finite, then this limit is known as the probability of happenings of that event."

The relative frequency of an event is equal to the ratio of the number of times the event happens (X) to the total number of trials (N) i.e., $\frac{X}{N}$. This ratio will assume a definite value, as the number of trials (N) increases and thereby the value of X is changed (increased). For instance, if a fair coin is tossed, 10 times, 100 times and 1000 times, one may observe the number of heads to be 2,40,475 respectively; and therefore, the respective relative frequency would be 2/10, 40/100 and 475/1000. This demonstrates that as the number of trials increases, the relative frequency approaches 1/2.

However, no event is inherently probable. An event may be probable in terms of its belonging to a specified class; and this should be explicitly known before evaluating probability. In this theory, probability is defined as the relative frequency with which the members of a class exhibit a specified property. The same event, however, can be assigned different probabilities in different situations. It should be remembered that the probability should be relative to the evidence at the disposal. An event will have different probabilities relative to different amounts of evidence. But in judging probabilities, it will be a mistake to use less than the total amount of available evidence.

The frequency theory is not capable of interpreting what we mean by the probability of theory being true, or by the probability of propositions that are concerned with singular events. But these objections are not serious, and they can be overruled by modifying the technical aspect of the frequency theory.

However, since probability is relative by nature, it is useful to apply probability calculus in the analysis and measurement of probability.

Mathematics or Calculus of Probability

In a sense, the conception of probability is essentially a mathematical one. It is purely mathematical if it is restricted to the question of necessary inference. A few elememtary theorems are mentioned below :

1. The mathematical probability of a simple event is expressed as the fraction whose numerator is the number of favourable events (M), and denominator, the total number of alternatives (M+N).

Or, P (Probability of the happening of the event) $= \frac{M}{M+N}$

The events are assumed to be equiprobable.

The sum of the probability of success (P) and failure (q) is $=1$. The value of the probability, which is expressed in fractions, lies between 0 and 1.

2. The probability of the occurrence of the two independent events, is the product of their separate probabilities. Thus, if X and Y are two independent events, P (x) the probability of the first, and P (y) the probability of the second, the probability of their joint occurrence is $P(xy)=P(x)\,P(y)$. This rule is applied even if the events are not completely independent.

3. The probability of the occurrence of either of the two events that cannot concur (i.e., exclusive events), is the sum of their separate probabilities. For example, if P (x) and P (y) are the respective probabilities of two exclusive events X and Y, the probability of obtaining either is $P(x+y)=P(x)+P(y)$.

If two coins X and Y are tossed together, the possibilities of the falling of head (success, P), and tail (failure, q) are :

X and Y both falling heads,
X falling head and Y tail
X falling tail and Y head
X and Y both falling tails.
The probabilities of :
Two heads (or 2 successes) $=P.P=P^2$
One head and one tail (only 1 success) plus
One tail and one head (only 1 success)
$$=Pq+qP=2Pq$$
Two tails (or 0 success) $=q.q=q^2$

Here, the probabilities of 0, 1 and 2 successes are given by q^2, $2qP$, and P^2 respectively i.e., by the successive terms of the expansion of the binomial $(q+P)^2$.

Binomial expansion takes the general form $(P+q)^n$, where n is the number of events. In this case, the probability of a complex event with n components can be obtained by selecting the appropriate term in the expansion of this binomial. When this type of binomial is expanded, the number of combinations increases and the frequencies of each form a perfectly smooth symmetrical curve known as the probability curve or, the curve of normal distribution. This curve is fundamental in the analysis of probability statistics.

4. The probability of cumulative evidence being true, may be calculated by subtracting the product of the separate improbabilities from unity. For instance, if the probability of a witness telling the truth is 9/10 and the probability of the second witness telling the truth is 1/5, then, the improbabilities in these two cases would be 1/10 and 4/5 respectively. The product of these improbabilities would be 2/25. By subtracting this product from unity,

we get 23/25. Thus, the cumulative value of the evidence, i.e., the probability of the event having actually occurred is 23/25.

Mathematics is not concerned with the truth or falsity of the premises as such. No purely mathematical theory can perfectly determine the degree of probability of any proposition, dealing with matters of fact. When certain assumptions are made explicit regarding a proposition, mathematics can determine the probability. It can examine the necessary consequences of these assumptions.

All said and done, it must be admitted that the probability of the theory of probability is very improbable.

Keynes' Ideas on Probability

Keynes' ideas on probability may be found in his *Treatise on Probability* (1921) and in his *General Theory* (1936). In the *General Theory*, Keynes discusses probability with reference to long-term expectations.[3] He says that in forming expectations, it is not proper to attach too great a significance to the matters which are very uncertain. Keynes does not regard uncertainty as improbability.[4] The state of long-term expectation depends not only on the most probable forecast, but also on the confidence with which one makes this forecast. Over a long period of time, the actual results of investment hardly agree with the initial expectation. The existing market valuation is not uniquely correct, because the existing knowledge does not provide the sufficient basis for a calculated mathematical expectation. We cannot rationalise our behaviour by arguing that to an ignorant man, errors in either direction are equally probable, so that there remains a mean expectation based on equi-probabilities. Keynes observes that "the assumption of arithmetically equal probabilities based on a state of ignorance leads to absurdities."[5]

However, a more thorough treatment of probabilities by Keynes can be found in his *Treatise and Probability*. The fundamental problem connected with the theory of probability is the interpretation of probability. What exactly is the thing whose value is known *a priori* or revealed through the measurement of relative frequency ? Some logicians observe measurement does not go to find the simple numbers alone, but it finds numbers in relation to characteristics that are definable. One must know, therefore, the characteristics which find their numerical expression in the context of probability. Probability being, to some extent, a subjective valuation, the facts that lead to variations in the state of mind must be understood. This is essential for a proper understanding of

3. J.M. Keynes, *General Theory*, Ch. 12.
4. *ibid.*, p. 148 (fn. I.)
5. *ibid.*, p. 152.

the nature of probability; and Keynesian analysis is mainly devoted to this consideration. His contribution to the theory of probability lies in the fact that he has given greater definiteness to the loosely used word "Probability."

Probability may be viewed in the mathematical, statistical or logical sense. In the purely mathematical sense, the actual value for the probability is either known or assumed to be known, *a priori*; and then one has to make an arrangement mathematically on the basis of different values obtained. In the statistical sense, when the actual probability is not known *a priori*, an attempt is made to estimate probability *a posteriori* on the basis of actually observed statistical frequencies. However, in the logical sense, the treatment of probability involves problems which partly belong to the domain of psychology rather than completely to the area of pure logic.

According to Keynes, probability is not concerned with events other than propositions or judgements. In form, Keynesian analysis of probability is symbolic; but in actual practice, he rules out the possibility of mathematical measurement of probability. To Keynes, probability is not a measure of anything; but it is simply a manifestation of an undefinable logical relationship between two involved statements. This logical relationship has two extremes; at the one end, there is full certainty (probability=1), and at the other, there is complete uncertainty (probability=0). However, corresponding to this logical relationship, there may be some actual relation—a causal relation of some nature, as the probability value approaches zero or one.

Probability is based on induction. But inductive arguments were the real targets of attack of the mathematicians in the past. It was not that the inductive methods were false but that their validity, was not established. In this connection Keynes introduced his principle of "Limited Independent Variety." This principle says that the world may not be finite but any property in it can enter only into a finite number of combinations. But if this number is very small, then it will not be able to reflect the complexity of the real world in sufficient degree. The difficulty faced in measuring probability cannot be solved or avoided by Keynes' principle. It is generally said that if the evidence to justify a probability assertion is not sufficient, then the assertion can however be established by referring it to the principle of Insufficient Reason (Equal Distribution of Ignorance). According to this principle, the unknown *a priori* probabilities must be equal when, due to our ignorance, we cannot assign unequal values. Keynes observes that when the probability of an event is not known before-hand, we may regard all possible values of the probabilities, between zero and one, to be equally *a priori*. But Keynes' argument here does not seem to be very sound. Keynes wanted to formulate the principle of Insufficient Reason in a more precise manner. He

observed that this principle can be used only till such time as it is appreciated that it cannot be applied to a pair of alternatives, either of which is capable of being further split up into a pair of incompatible alternatives having the form of the original pair.

Be that as it may, Keynes' contribution to the theory of probability was outstanding and original. To him, probability belongs to that part of logic which deals with arguments that are rational but not conclusive. Keynes had been following the English tradition of Hume, Mill and other noted logicians who preferred matters of fact, and conceived logic as a branch of Science rather than of imagination. The entire approach of Keynes, so to say, is based on the principles of logic. He sets out from the basic principles of logic to achieve the following objectives:

(i) the examination of the methods of analogy and introduction.

(ii) deduction by the rules and symbolism of formal logic in order to facilitate mathematical functions in the theory of probability.

(iii) the development of probable knowledge.

(iv) the creation of a sound basis for the growth of statistical inference.

Keynes' ideas on the philosophy of science, and on probability and induction opened up new avenues of thought and people expressed intellectual indebtedness to Keynes for his novel ideas in the realm of the logic of science. Thus, R.B. Braithwaite, a celebrated scientist, dedicated his work, *Scientific Explanation*, to the memory of J.M. Keynes.

16

UNIFORMITIES, GENERALISATION AND LAWS

Uniformity speaks of order. There is uniformity in Nature. Laws in science express uniformities. A Science aims at discovering laws and thereby uniformities.

Meaning of Uniformity

Uniformity may mean uniformity of causation. This meaning is hypothetical in form. If the same cause occurs, it will have the same effect. It is not said whether the same cause will occur or not. The second meaning of uniformity is: the course of Nature will be the same in future, as it was in the past. That is the unknown, will be like the known. But this interpretation is not based on scientific reasoning. We cannot say with certainty that since the sun has risen today, it will also rise tomorrow.

Paradox of Induction

The law of Uniformity of Nature is regarded as the formal ground of Induction. The truth of the principle of uniformity cannot be proved, but it must be pre-supposed. However, sometimes it is also believed that the principle of uniformity itself is an instance of induction. It is the result of induction by simple enumeration. The principle of uniformity is based on experience and induction, and is also the basis of induction. Thus, we face a paradox: The ground of induction is itself an induction.

Types of Uniformities

Uniformity of Co-existence: When certain properties or attributes exist side by side, then we say that there is the uniformity of co-existence. For instance, "All crows are black", "Water is colourless" etc. Here, certain properties are regularly found together. The laws which express such uniformities are known as

Laws of Co-existence. Class-name indicates that a certain uniformity of co-existence has been found. For instance, if certain specified properties e.g., absence of colour, are found in a liquid, it may be called water; otherwise not. The class-name is given on the basis that certain attributes or properties are found to co-exist in that thing. And, in this way, an order among thing is discovered.

Uniformity of Sequence or Succession : This involves order in time and causation. Here, one thing follows another. One thing may come before—antecedent, and the other thing may come after—consequent. In co-existence, the properties or attributes exist side by side at the same time. But in succession, one thing comes after another. For instance, lighting is followed by thunder. Through this type of uniformity we can find causal order or order of sequence of events. Cause-effect relationship is expressed by the uniformity of sequence.

Uniformity of Equality or Inequality: (*Uniformity of the Mathematical Equation*) : This uniformity is the basis of Mathematics. In mathematical equations, we find a certain type of uniformity i.e., a particular constant relationship which is quantitative. On the basis of such relationship, the causal laws can be replaced by mathematical functions. Here, the discovered order is the order of a quantitative relationship. For instance, Ohm's law regarding electricity states that the current is equal to the potential difference divided by the resistance.

However, Carveth Read has pointed out some more fundamental uniformities:

(i) *The Principle of Contradiction and Excluded Middle.*

(ii) *Some Axioms of Mediate Evidence* e.g., Aristotle's "*dictum de omni et nullo.*"

(iii) *Uniformity of Time and Space.* It says that it is possible to definitely measure all spaces and times.

(iv) *The Persistence of Matter and Energy.* It is stated that in all changes in the universe, the quantities of matter and energy remain the same.

(v) *Law of Causation.*

However, it must be noted that induction deals with all these uniformities, but practically, the law of causation remains most important.

Generalisation

A science aims at generalisation or inference of a general proposition on the basis of observation of particular instances. The

generalisation is made possible by the employment of experimental method which helps us in establishing a causal connection between things.

Basis of Generalisation

A science is concerned with the generality of things. It wants to find out the truth, not regarding a single object or individual, but regarding the classes of objects or events. When the truth is discovered in a science, it is expressed in the form of generalisation. A generalisation is a general proposition regarding classes, objects or events, or the existence of a definite relationship among certain types of events or objects or classes. A generalisation being a general proposition, is applicable to the entire class of objects or events and, of course, the individual cases are included in the class to which they belong. The basis of scientific generalisation is the assumption of order in Nature. Order in Nature means the existence of uniformities in the characteristics of objects or events, or it may mean the regularity in the happenings of certain events.

There are various types of order in Nature, e.g., invariable association of properties, causal order, mathematical relationship and systematisation (for details regarding the types of order in Nature, see the chapter on *The Meaning and Nature of Science*).

Nature of Scientific Generalisation

The discovery of the order in Nature finds expression in the form of generalisation in a science. A scientist gives a general explanation of the objects, events or phenomena observed. The ultimate task of a scientist is to generalise.

The result or the end-product of a scientific investigation is the generalisation. Any scientific knowledge ends in generalisation. Generalisation indicates the completion of a scientific investigation for the time being. When new facts or new knowledge is gathered, the investigation may be continued further. And as a result of the new investigation, the old generalisation may be modified or even given up. Thus, no generalisation in science is once-for-all generalisation.

Generalisations may be taken as the media of collecting fresh and new knowledge about different phenomena. Generalisation itself helps to bring new facts and new knowledge. The present generalisation may become the basis of future investigation into facts and circumstances, and therefore, it may be the basis of future generalisation.

Scientific generalisations, however, speak of the tendencies or uniformities. They are neither certain nor permanent. Scientific generalisation is, more often than not, based on induction i.e., on the process of arriving at unknown facts from known facts. Such a

jump leads to uncertain results. In making a generalisation, all the unknown cases are not observed and studied. Thus, generalisation is only probable or approximate. Scientific generalisations are uncertain, provisional or tentative propositions. These generalisations are not permanent but temporary in nature, because whenever new knowledge or new facts are collected, the old generalisations may have to be modified. However, there are invariable generalisations which are universally true, so far as experience goes, e.g., "All material bodies fall to the earth." The generalisation is invariable because the relation between the subject and the predicate is regarded as universal.

Approximate or probable generalisations are useful where universal proposition cannot be found. Such generalisations may be made useful in a science with the help of statistics. For instance, if it is found that 90 per cent of the vaccinated persons are not attacked by small-pox at the time of epidemic, it may be inferred that vaccination prevents small-pox.

Types of Generalisation

There are two broad categories of scientific generalisation:

Empirical Generalisation: This type of generalisation is based on empirical observation or experience. The main task of this generalisation is to describe the phenomena as experienced or observed by the scientist in the process of investigation. It describes the regularities of occurrence or the observed uniformities of events. This generalisation does not say as to why the situation has happened, but it simply describes the situation. For instance, by collecting data, an investigator can say by how much percentage the population has increased during the plan period, but he does not say, in this type of generalisation, the causes of population growth. Empirical generalisation is the basis of further investigation into the causes of the phenomenon observed by the scientist. This type of generalisation characterises the early stage of a science; and becomes the basis for the formulation of possible hypothesis regarding the phenomenon.

Explanatory Generalisation: This type of generalisation provides the explanation for the tendencies, regularities or uniformities observed by the scientist. It explains the cause of the phenomenon. After analysing facts properly, this type of generalisation is arrived at. This generalisation is the end-product of a scientific investigation. It is the next step to empirical generalisation; and it occupies a higher place in a scientific investigation. This is so, because a science is, after all, a systematic body of explanation.

Laws

The word 'law' has various meanings. It may mean a command of a superior authority, or a mere uniformity, or a

standard or ideal. In a science, law refers to an expression of some order in Nature.

Classification of Laws

Laws are broadly classified into three categories:

1. *Axioms*: Axioms are real, universal and self-evident propositions. Axioms are self-evident. They do not require any proof, nor are they capable of any proof.

2. *Primary or Ultimate Laws*: They are less general than axioms but they represent the highest point reached by sciences. These laws are subject to proof. The Law of Gravitation is a primary law.

3. *Secondary Laws*: Secondary laws are generally derived from primary laws. They are either derivative or empirical. They are less general than primary laws. The three laws of Kepler are secondary laws because these are derived from the Law of Gravitation. Invariable of approximate generalisations are secondary laws. Carveth Read divides secondary laws into: (i) Laws of Succession and (ii) Laws of Co-existence.

Laws of Nature

The entire world is a system of laws. There are different laws that govern the different phenomena of Nature. There are definite laws of Nature, and these laws are connected to one another, and further into a system. Nature reveals uniformity and unity. This means that there are uniform relations existing between various phenomena of Nature. Law of Nature simply implies the uniformity of Nature. Laws of Nature are also called laws by analogy. Laws of Nature cannot be altered, modified or violated. It is positive, because it explains how natural phenomena actually behave. The Nature's laws are not imposed by any superior authority. Moral laws are normative i.e., they say "how it should be," but natural laws do not say so, rather they explain "how actually it is." A natural law, i.e., a law of science, is "nothing more than a regularity of uniformity in the character or relation of certain classes of facts or events" (Wolf).

Empirical Generalisation and Law of Nature

Empirical generalisations are based on observed facts. Therefore, in a sense, scientific laws are empirical generalisations. 'Law of Nature' implies a certain order or uniformity in the phenomena of Nature. It is the business of a science to discover the uniformity or order in Nature. The laws of science express laws of Nature. But scientific laws are empirical generalisations. Thus, Laws of Nature, in a way, are empirical generalisations.

However, the Laws of Nature are not merely empirical generalisations—they are something more. A science not only describes but also explains. Empirical generalisation in the ordinary sense is only a description of instances. When generalisation is explanatory with regard to the involved instances, it can be called a scientific law or a Law of Nature. When the empirical generalisation can be deduced from a more comprehensive generalisation or law, then it can be called the Law of Nature. For instance, the generalisation that "All men are mortal" is based on the empirical cases of men dying. But this generalisation can also be deduced from the more comprehensive law which says that "All living beings are mortal." Thus, our former empirical generalisation that "All men are mortal" becomes a law of Nature. A scientific theory is, therefore, a deduced system. Prof. Braithwaite observes that if we are to consider whether or not a true scientific hypothesis would be a Law of Nature, we are to consider the way in which it could enter into an established scientific deductive system.[1]

Nature of Laws of Social Sciences

The laws of social sciences, like the law of physical sciences, express uniformities. But the nature of uniformities expressed by the laws of social sciences is different from the nature of uniformities expressed by the laws of physical sciences. The laws of social sciences do not express exact uniformities; they simply express a tendency or a satistical average. Such laws cannot be falsified by a single negative instance. The laws of physical sciences express exact uniformities, and a single negative instance is enough to falsify a law of a physical science.

In a social science like Economics, laws or generalisations are the statements of tendencies. There are no tendencies in a social science, which act steadily and can be measured as exactly as Gravitation can be. The laws of social sciences are to be compared with the laws of the tides, rather than with the simple and exact Law of Gravitation. Since in social sciences human actions are involved, which are bound to be varied and uncertain, the statement of tendencies is necessarily inexact and faulty. Laws of social sciences are hypothetical in nature. For instance, economics studies the effects which will be produced by certain causes, not absolutely, but subject to the condition that other things remain equal. Laws of social sciences do not have the power of prediction. There are always some socio-institutional and political environments in which the laws of social sciences operate in a particular way. Generalisations of social sciences are essentially historico-relative in character, and their validity is limited to only certain historical conditions. Lack of exactness, and inadequate predictability of a social science make its laws imperfect and limitedly applicable.

1. R.B. Braithwaite, *Scientific Explanation*, p. 303.

Abstraction

All our thinking involves abstractions. In abstraction, we state only the general characteristics which are common with other things. Abstraction presupposes analysis. It involves the method of selection of elements that are not given in isolation. Some elements can be related to other elements. This type of relationship gives empirical generalisation. Generalisation involves abstractions. Every science at the classificatory stage involves abstractions which are expressed in general propositions. When abstraction becomes more and more perfect, science proceeds from the stage of classification to one of causal investigation. At this stage, measurement can be applied to a science. The science of mathematics is a form of complete abstractions. However, social and biological sciences involve lesser number of abstractions. Mathematical abstraction is applied to perceptible object in a process of extensive abstraction. Extensive abstraction involves the principle of convergence to simplicity. This principle points out that any complex occurrence can be regarded as something which can be analysed into homogeneous units. The law of these units can be expressed in quantitative terms. Thus, a complex phenomenon is reduced to a simple law. The causal laws are sometimes replaced by mathematical functions. These functions express tendencies. This process shows that the abstract deductive system can be helpful for explaining the phenomenon of the real world.

SELECT QUESTIONS

Chapter 1

1. What is a Science? Give some Characteristics of Science.
2. Explain the fact that a Science is a chain of Models.
3. Discuss the importance of Value Judgement in Science.
4. What are the limitations of Science?
5. Give some recent views on Science and also point out the presuppositions of Science.
6. Is there any order in Science? Explain.
7. Discuss the meaning and nature of the Human Knowledge. How is a scientific knowledge different from ordinary knowledge?

Chapter 2

1. "Nature of Science determines the Methodology." Explain.

3. What are analytic and synthetic methods? Explain their nature.

3. Discuss the methodologies of some sciences.
4. Write short notes on:

   Comparative Method
   Genetic Method
   Historical Method
   Descriptive Method
5. Discuss the meaning and nature of Scientific Method.
6. Elaborate the use of Scientific Method in Social Sciences.
7. What are the limitations and abuses of Scientific Method?

Chapter 3

1. What is a hypothesis? Discuss the conditions of the valid hypothesis.

2. What is meant by verification of hypothesis? Distinguish between proof and verification. How will you test a hypothesis?
3. Discuss the role of hypothesis in Science.
4. Write short notes on:
   Theory
   Fact
   Law
   Null Hypothesis.

Chapter 4

1. What is meant by saying that deduction and induction are complementary to each other?
2. Discuss the Merits and Demerits of deduction and induction.
3. What is perfect induction? How is deduction related to induction?
4. Write a short note on Hypothetico-Deductive Method.
5. Distinguish between deduction and induction. Is perfect induction possible?

Chapter 5

1. Bring out the distinctive nature of observation and inference, and point out their comparative significance in scientific investigation.
2. Distinguish between observation and experiment, and bring out the advantages of observation over experiment.
3. What is experiment? Discuss the steps required in experimental technique.
4. Give some experimental designs used in social science research.
5. Discuss the conditions and fallacies of observation.

Chapter 6

1. What is inference? Discuss the nature and type of inference.
2. Is immediate inference inference? Explain.
3. Distinguish between Implication and Inference.
4. Write short notes on:

Probable Inference
Paradox of Inference
Conversion
Obversion
Oppositional Inference.

Chapter 7

1. What is Definition? What is its purpose? Explain how the definition of a term goes on changing from time to time.
2. "Definitions are dynamic in nature." Discuss.
3. Discuss the importance of classification and description in scientific investigations. What is their scope in Commerce?
4. What is a nominal definition? How does it differ from a real definition? Give examples.
5. What are the main types of classification in scientific method? Give examples.
6. "All description is classification." Explain.
7. Discuss different types of Definition and bring out the psychological motives of definition.
8. Explain by means of examples the meaning of genus and differentia.
9. Write short notes on:

   Deductive and Inductive Definitions

   Genetic Definition

   Theory of Predicables

Chapter 8

1. What do you understand by 'explanation'? How does it differ from description? What are the main types of scientific explanation? Give examples.
2. Discuss the limits and value of explanation in science.
3. What do you mean by Evolutionary explanation? Elaborate.
4. Write short notes on:

   Teleological Explanation

   Analogy

   Models

5. What is a Model? Discuss the types and functions of a Model. Distinguish between analogy and model.
6. Bring out the importance of Models in theoretical science.

Chapter 9

1. What do you understand by 'analogy' and 'hypothesis'? What is the role of analogy in the formation of hypothesis ?
2. Explain with the aid of examples what is meant by misuse of analogy.
3. Bring out the distinction between analogy and fair sampling, and elaborate the role of fair samples in induction.
4. Write short notes on :

   Positive Analogy
   Negative Analogy
   Neutral Analogy

Chapter 10

1. What is law of causation ? Bring out the relation between law of causation and the uniformity of nature.
2. What is a cause ? Give some characteristics of cause.
3. Distinguish between cause and condition, and cause and function.
4. Why is a modern scientist averse to using the concept of cause ? Explain fully.
5. What do you understand by 'function' ? How is it different from cause ?
6. Write short notes on :

   Plurality of Causes
   Aristotle's View of Cause
   Popular View of Cause
   Scientific View of Cause
   Modern View of Cause.

Chapter 11

1. Give an evaluation of Mill's Methods as methods of discovery and proof.
2. In what way is the Joint Method of Agreement and

Difference an improvement upon the Method of Agreement? Discuss.

3. Is the Method of Residues an inductive method ? Discuss.
4. Explain and illustrate the Method of Concomitant Variation. What are the special features of this Method ?
5. What is the method of Difference ? What are its special features ? Answer with the help of examples.
6. Discuss the different methods of induction and point out their limitation in discovering causal connections.
7. How are the Methods of Agreement and the Methods of Difference helpful in discovery and proof ?

Chapter 12

1. What is a Concept ? Discuss its categories.
2. What are the features of a Concept ? How will you use a Concept ?
3. Discuss the importance of the formulation of Concept in scientific investigation.

Chapter 13

1. What is Measurement ? Discuss its purpose and conditions.
2. How will you measure Qualitative Data ? In this connection discuss the methods of measurement of intensive and extensive qualities.
3. What is Measurement ? How will you measure quantitative and qualitative phenomena ?
4. Write short notes on :

   Content Analysis

   Categorisation

   Numerical Laws
5. How will you ensure validity and reliability of Measurement ?
6. Distinguish between the Measurements of Intensive Quality and Extensive Quality.

Chapter 14

1. What is statistical methods ? Explain the need for a statistical method.

2. What steps are necessary in statistical methods ? Explain.
3. Write an essay on the application of Statistical Method.
4. Discuss the uses and misuses of Statistics.
5. What dangers and fallacies are associated with the use of Statistics ?
6. Write short notes on :
   Fallacies in Statistics
   Simple Enumeration
   Distrust of Statistics

Chapter 15

1. Comment on the statement : Generalization from experience is an uncertain inference.
2. Why is a single instance sometimes sufficient to establish a universal conclusion, while in other cases the greatest possible number of instances which verify a hypothesis without exception are not sufficient ?
3. What is Probability ? Discuss its nature and basis.
4. Elaborate the concepts of Probability as a Measure of Belief and as relative frequence.
5. Write an essay on Keynes' ideas on Probability.
6. Bring out the importance of Probability in Inductive Generalisation.

Chapter 16

1. What do you understand by 'Law' ? What are the various types of Laws ?
2. Discuss the characteristics of laws of nature and empirical laws with suitable examples.
3. What do you mean by Uniformity ? Discuss its types.
4. What is Generalisation ? What is the basis of Generalisation ?
5. Bring out the nature and types of Scientific Generalisation. Discuss the connection between empirical generalisation and law of nature.
6. Write an essay on the nature of laws in social sciences.
7. Write short notes on :
   Abstraction
   Paradox of Induction
   Classification of Laws
   Laws of Nature
   Empirical Generalisation.

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Jacket design : S. Moolchandani
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